POWER

Vol. 39 NEW YORK, JANUARY 27, 1914 No. 4

Initiative

THIS is not a new subject, but it is so important to the engineer as to warrant its reiteration.

It is initiative which makes the individual's head stick out above the general mass, where it may be struck by the lightning of advancement.

What profession presents a better field for original thought and action—for *initiative*—than the operating engineer's? Yet, perhaps in few fields is there a greater lack of originality in thought and action.

A prominent railroad official has stated that during a term of years extending over a quarter of a century the operating department of his road showed no record of any suggestion by any engineer, brakeman or conductor for improvement of the company's train service. Every suggestion of this character had come from patrons of the road, and from the higher officials.

The employer of an engineer will never know that he can sing, unless the engineer occasionally tries out his voice in the employer's presence.

[*By Harry B. Goodwin, Holyoke, Mass.*]

Tallulah Falls Hydro-Electric Development

By Warren O. Rogers

SYNOPSIS—This plant, 89 miles from Atlanta, Ga., is operated with a 600-ft. head, the highest in the South. The five turbines are the highest powered in the United States, having developed 18,600 hp. under test. The generators are of 8000 kw. capacity, 80 per cent. power factor. Water, impounded by a concrete dam 700 ft. long and 110 ft. high, provides a supply basin, from which the water flows through a 6670-ft. tunnel to a surge basin from which five 5-ft. steel penstocks lead to the turbine wheels. Electrical energy is generated at 6600 volts and sent out on the line at 110,000 volts to the open-air transformer station, at Atlanta, the largest of its kind in the world.

It has been predicted that within the next decade Atlanta, Ga., will be a smokeless city; a possibility, because of the abundant water power available within a radius of 100 miles, which warrants a waterwheel installation of

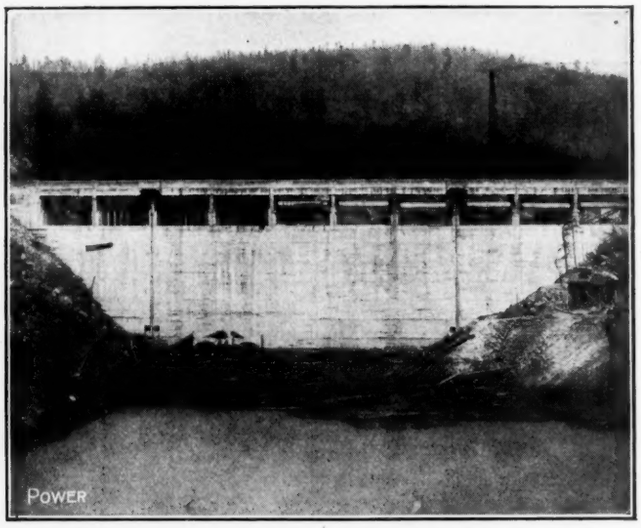


Fig. 1. Upstream View of Dam and Counterweight Flashboards

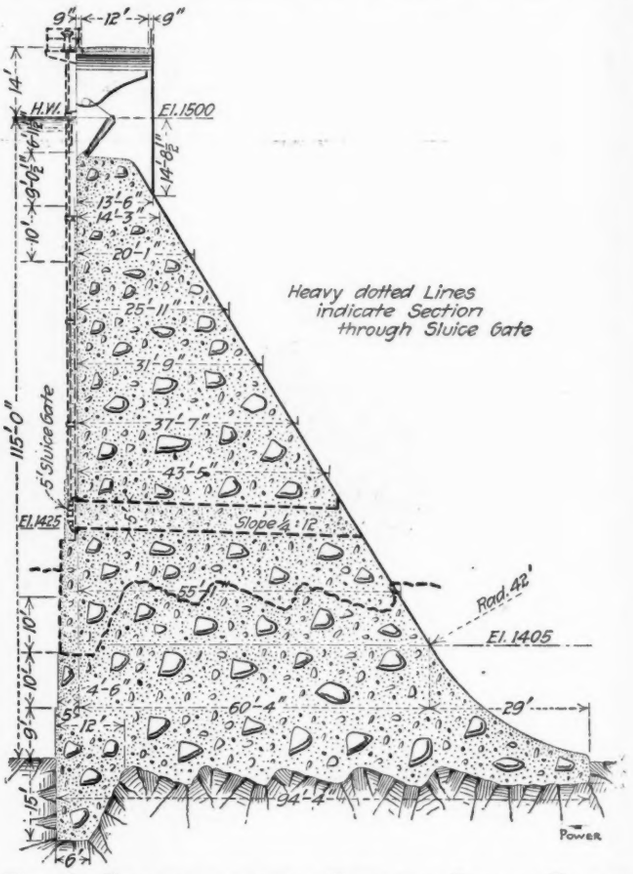


Fig. 2. Section through Concrete Intake Dam at Tallulah Falls

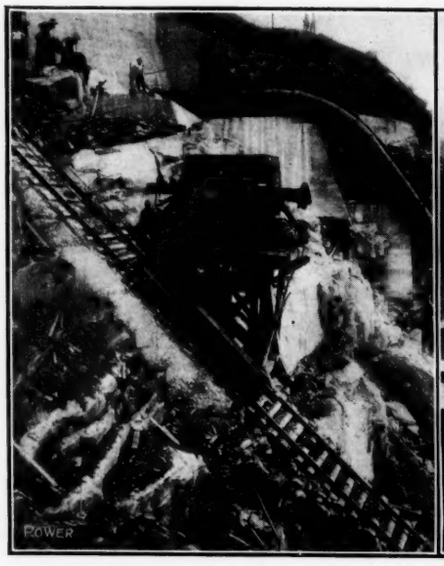


Fig. 3. Remote-Controlled Valves at Head of Penstocks

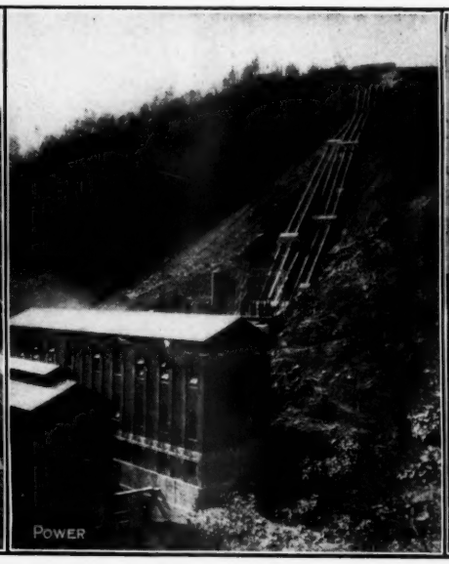


Fig. 4. Penstocks and Concrete Anchorage Blocks

Fig. 5. Venturi Meters and Steel Bridge Towers

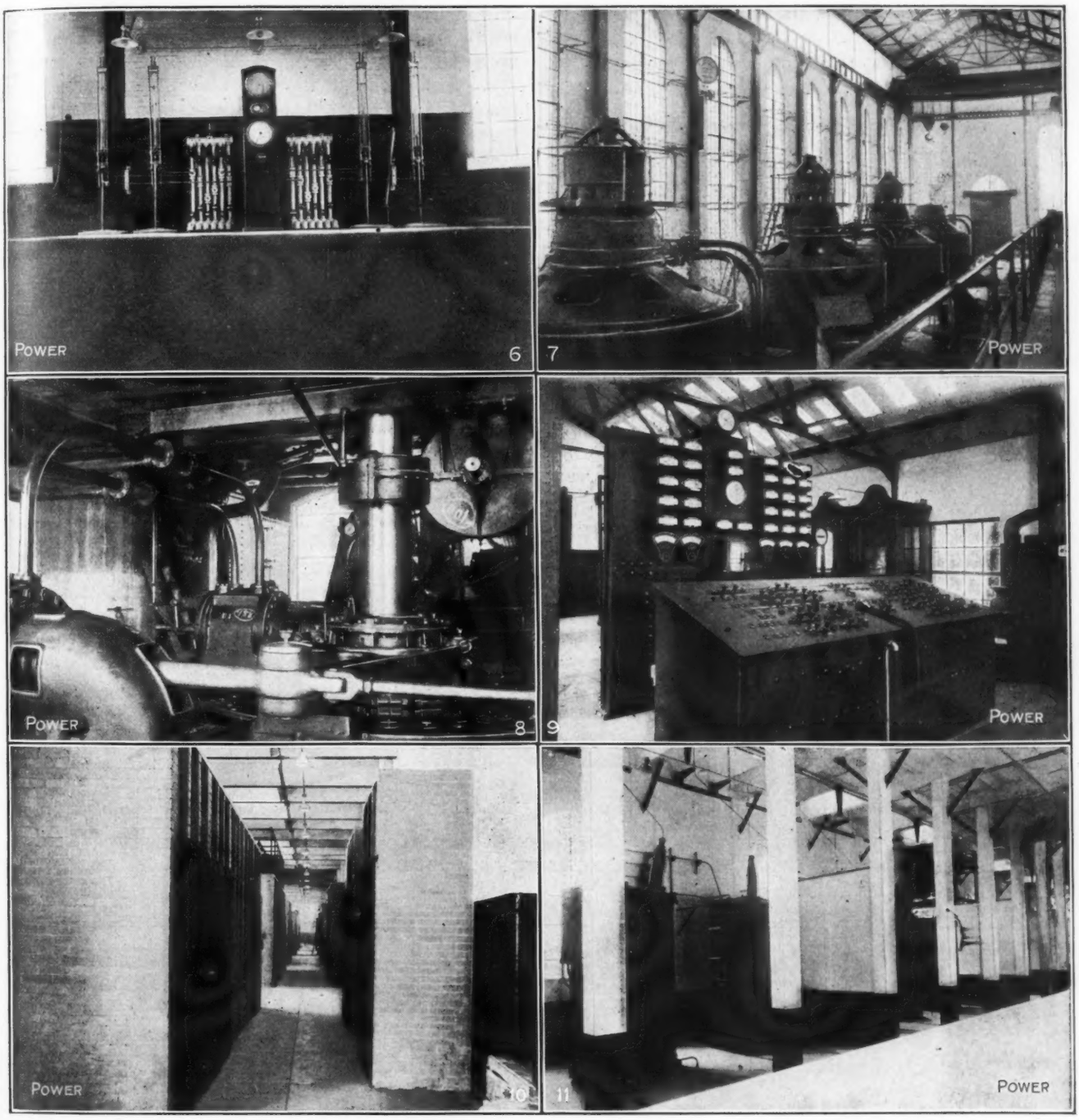


FIG. 6. VENTURI INDICATING AND RECORDING INSTRUMENTS. FIG. 7. PARTIAL VIEW OF THE GENERATOR ROOM AND FOUR 8000-KW. GENERATORS. FIG. 8. HYDRAULICALLY OPERATED WATERWHEEL GATE. FIG. 9. BENCHBOARD IN SWITCH-CONTROL ROOM. FIG. 10. LOW-TENSION BUSBAR AND OIL-SWITCH ROOM. FIG. 11. TRANSFORMERS OF 3333 KV.-A. CAPACITY EACH

approximately 1,600,000 hp. If all of the available developments within 190 miles of the city are taken into consideration, there will be a total waterwheel installation of approximately 3,170,000 hp.

Of the numerous water-power sites, the Georgia Railway & Power Co. owns 10, with a total waterwheel capacity of 345,000 hp. Of these, five are on the Savannah watersheds, four are on the Chattahoochie, and one is on the Etowah watershed. The power plant on the Savannah watershed, nearly completed and partly operated, is at Tallulah Falls, Ga., 89 miles distant in an air line from Atlanta, Ga.

DAMS AND STORAGE WATER

Storage water for this development is obtained by holding back the water coming from various sources by a storage dam at Mathis, about seven miles above the generator station, where a reserve storage of approximately 1,250,000,000 cu.ft. of water is held to be released for power purposes as the stage of water demands. This dam is of the Ambussen-deck type, 700 ft. long and 90 ft. high; and is provided with three 48-in. hydraulic gate valves to drain the reservoir of water.

The dam has been designed to house a small power plant of two 3000-kw. units which will utilize the energy

of the water released from the storage reservoir. This energy will be transmitted to the main power plant and from there sent over the main transmission lines for commercial use.

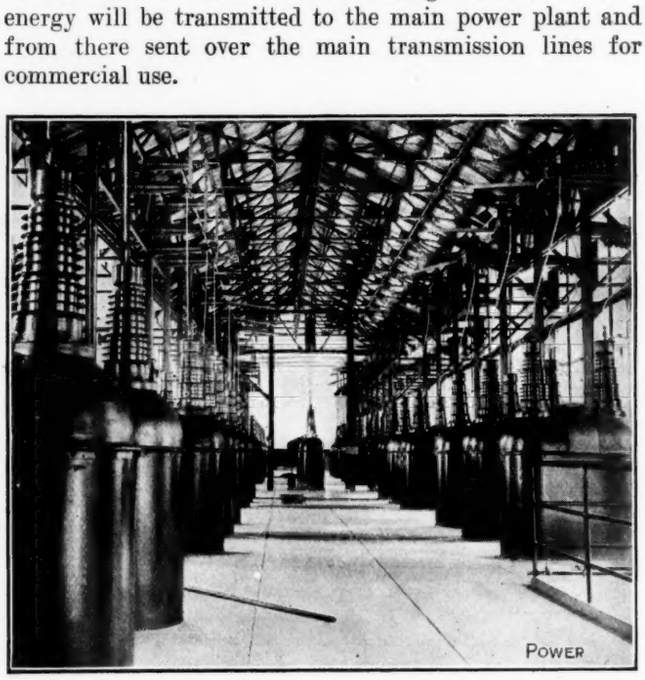


FIG. 12. HIGH-TENSION SWITCH AND BUSBAR ROOM

About one mile above the power plant is a second or main rubble concrete dam 110 ft. high and arched to a radius of 900 ft.; it is 444 ft. long on the crest. The spillway is 280 ft. long and is divided into 10 sections, as shown in Fig. 1. Each section is fitted with a swinging flashboard, hinged at the lower edge and controlled by a rolling counterweight so arranged that the water back of the dam will be maintained at within 3 in. of the normal elevation when discharging 12,000 cu.ft. per sec.

The flashboard counterweights are concrete cylinders 39 in. in diameter and 26 ft. long, and fitted at each end with a rack gear, which rolls on curved racks secured to the side of the piers above the crest of the dam. When the pressure of the water lowers the flashboards the counterweights are rolled up the incline by steel cables, which wind on a drum on the ends of the counterweights, and are connected at the other end to the top of the flashboards. The other four sections are to be fitted with built-up removable flashboards.

Another feature of this dam is the nine concrete piers, spaced 28 ft. apart, supporting a highway bridge, as shown. There is also a platform from which the flashboards can be operated by hand-operated hoists if necessary. Fig. 2 shows a section through the main dam and spillway.

TUNNEL AND PENSTOCKS

This dam creates a storage pond or forebay for the tunnel intake, which is built in solid rock from just above the dam to a point above the power plant. The intake head gates at the mouth of the concrete-lined, horseshoe-shaped tunnel are just above one end of the dam. The tunnel is 6670 ft. long with a net sectional area of 151 sq.ft. It discharges into a reinforced-concrete surge basin 96 ft. deep, 70 ft. long and 35 ft. wide. The walls are constructed of structural steel framework and concrete. From this basin five 5-ft. steel penstocks run to the power plant, 600 ft. below, which is built practically on the edge of the river bed in a deep gorge.

At the entrance of each penstock there is an emergency steel gate 7½ ft. square. The gates are hinged on a pin at the top side and held open by a chain- and hand-operated mechanism placed at the top of the surge basin.

At the upper end of the penstocks 60-in. remote-controlled, motor-operated valves are provided, Fig. 3, operated from the power house. Each penstock is anchored at the lower end by a cast-steel casing embedded in concrete. The anchorage is to take the thrust of the penstock and relieve the wheel casings of stresses. Each penstock, Fig. 4, contains an expansion joint just below the anchor blocks to take care of the expansion and contraction of the pipe line. Just outside of the switch house a venturi meter with a 35-in. throat is placed in each penstock, as in Fig. 5. The indicating and recording instruments are on a platform opposite the transformer bays in the switch house, Fig. 6.

Below each venturi meter is a hydraulically operated gate valve, 45 in. in diameter. The penstocks are fitted

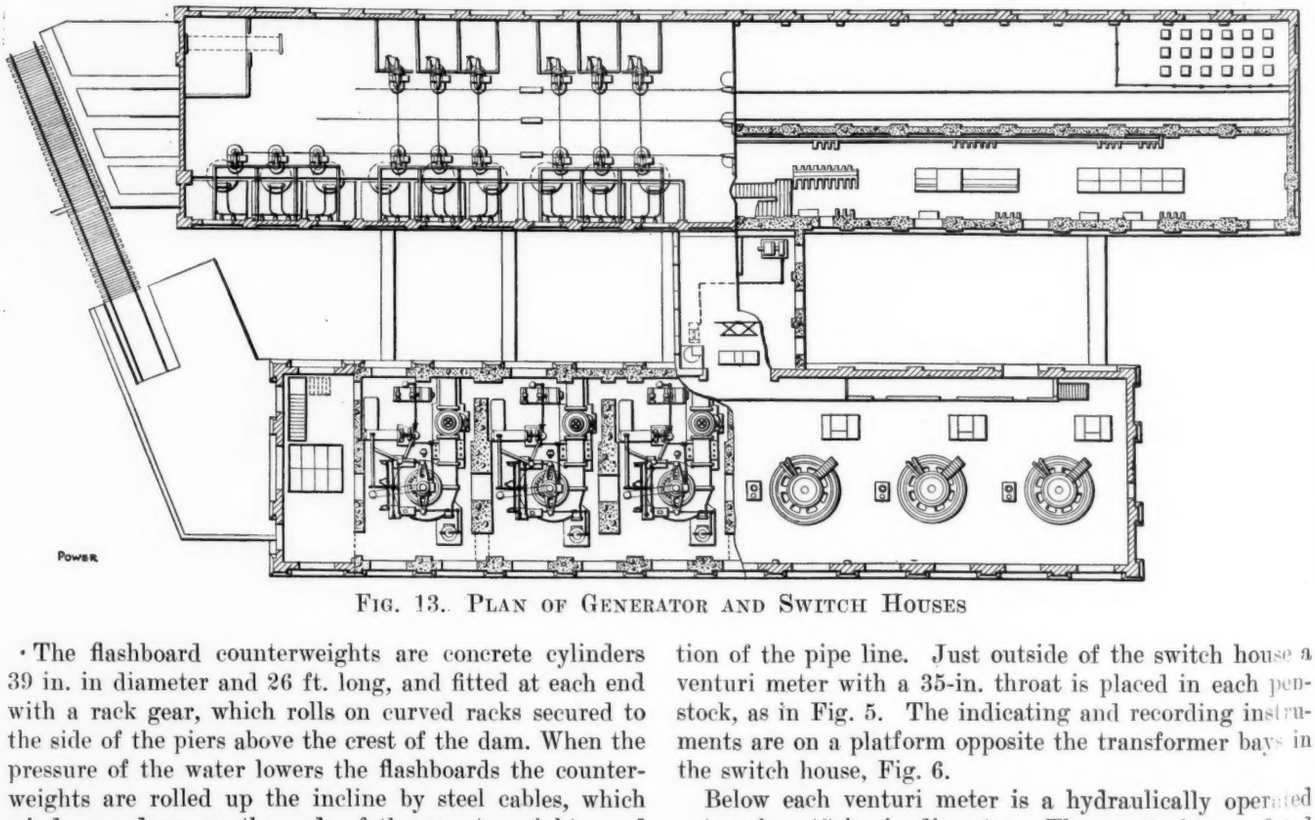


FIG. 13. PLAN OF GENERATOR AND SWITCH HOUSES

with an operating valve designed to be held in any position when the turbines are running. The head of water in the penstocks communicates with the cylinders and hydraulically operates the valves.

The penstocks are carried on concrete piers spaced about 30 ft. apart. Anchorage blocks of concrete are also provided at each change of grade for straight sections over 100 ft. in length. The maximum grade of the penstocks is 150 per cent. and the major portions are on grades exceeding 70 per cent.

Each penstock is made up of 400 ft. of riveted pipe, varying in thickness from $\frac{3}{8}$ in. at the upper end to $\frac{9}{16}$ in. at the lower, where it is joined to the 800-ft. length of the welded pipe, which is $\frac{9}{16}$ in. thick at the upper end and $\frac{11}{16}$ in. thick at the bottom.

Power Plant

The power station consists of two brick buildings, the main generating house and the transformer and high-tension switch house. The switch house is 28 ft. from the generator house. The latter is next to the river above the tailrace excavation in the river bed. The two buildings are connected by a bridge room in which is the switch-control apparatus.

In the generating building, which is 192 ft. long and 48 ft. wide, are five main generators, spaced 28 ft. apart, center to center, and space is available for a sixth unit. As would be assumed, the foundation is of heavy concrete, and the floor of the generator room is constructed of heavy steel beams to carry the weight of the generators. The roof of the building has a monitor extending nearly its entire length, and is covered by approximately 1200 sq.ft. of glass. The wall windows have steel sashes and glazed glass.

A 155-ft. gallery runs along one side of the generator room with a stairway at the ends to the generator floor. This gallery also forms the roof to the rheostat room.

The five main generators are of the vertical type and rated at 8000 kw., at 80 per cent. power factor, 6600 volts, 60-cycle, three-phase, and run at 514 r.p.m. On the dome of each generator is a 100-kw., 250-volt exciter, of a capacity sufficient to excite two generators at full load. A view of the generator room is shown in Fig. 7.

In the basement below the generator are the five 16,000-hp. vertical-shaft turbines of the Francis type, made by the S. Morgan Smith Co. They have, however, developed 18,600 hp. under test. These wheels are designed for a 600-ft. head of water. The speed is regulated by an oil-pressure governor with twin-gate-operated cylinders and a walking-beam to operate the gates. A partial view of the arrangement is shown in Fig. 8. The scroll case of each turbine is provided with a relief valve capable of discharging 70 per cent. of the water from the penstock in case of a sudden closing of the gate.

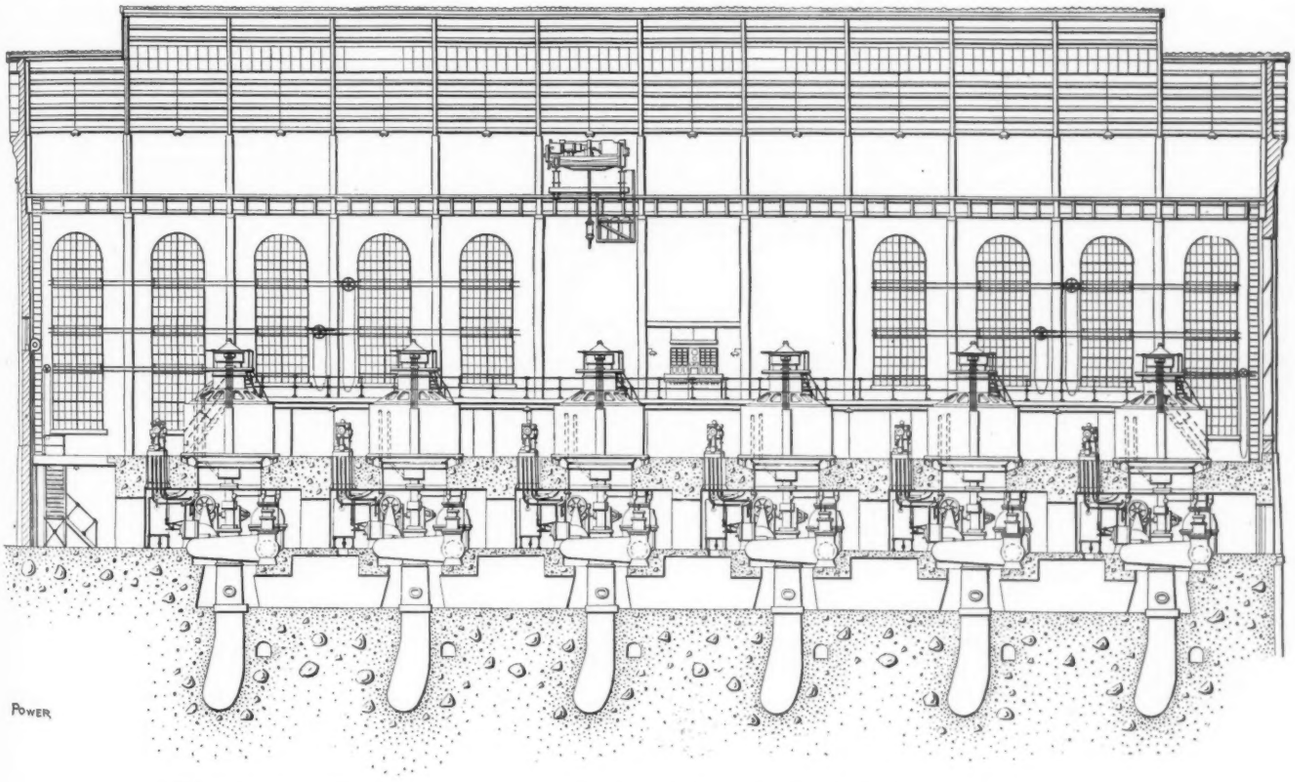


Fig. 14. Side Elevation of the Generator Room and Waterwheel Basement

The wheel runners are of bronze and the gates of steel. Each wheel case has a 14½-ft. outside diameter and weighs approximately 28 tons. Water is discharged from the turbine wheels through steel-lined concrete draft tubes with a normal draft head of 22 ft. on the runner.

The vertical nickel-steel shaft, carrying the turbine runner and the revolving field of the generator, is supported by an oil-pressure thrust bearing at the upper end of the shaft between the rotor and the exciter generator. There is also a guide bearing below the generator rotor and one above the turbine runner. In the rear of the basement are two Goulds 4½x8-in. triplex pumps; one operating the governor, the other supplying the thrust bearing with oil. One is driven by a chain from a countershaft, which is driven by a worm gear and worm from the generator shaft. The other pump is driven by a

geared 35-hp. motor. The thrust-bearing pump of each generator is so piped that any one can be operated with any generating unit.

The switch-control room, Fig. 9, which joins the generating and the switch houses and overlooks the generators, contains the instrument and integrating panels and a benchboard control of all service switches and signal lamps. The benchboard is laid out with miniature busses. On the main floor of the generator room under the control panels is one direct-current board upon which is mounted a remote-control field switch, operator's signals, etc.

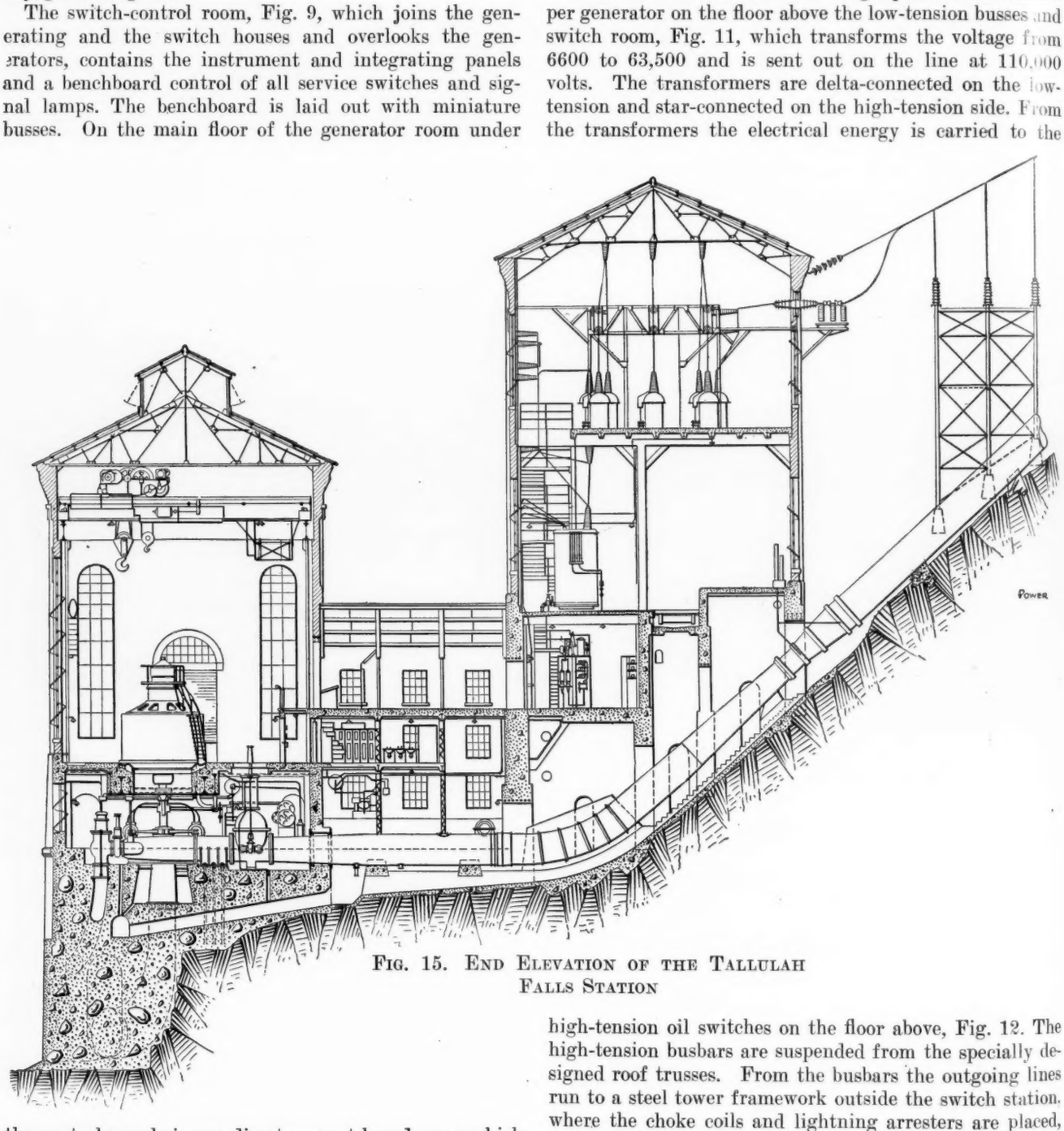


FIG. 15. END ELEVATION OF THE TALLULAH FALLS STATION

SWITCH HOUSE

Passing from the control room to the switch building the low-tension busbar room is entered, where the busbars and oil switches are arranged in brick compartments and barriers, Fig. 10. Each generator is isolated from the other, and the low-tension transfer busbar is the only connection between the low-tension switch room and the generators, the cables of which run to the switch house, where the oil switches are placed in groups, as shown. The switches are connected through the busbars to the step-up transformers.

There are three 3333-kv.-a. single-phase transformers per generator on the floor above the low-tension busses and switch room, Fig. 11, which transforms the voltage from 6600 to 63,500 and is sent out on the line at 110,000 volts. The transformers are delta-connected on the low-tension and star-connected on the high-tension side. From the transformers the electrical energy is carried to the high-tension oil switches on the floor above, Fig. 12. The high-tension busbars are suspended from the specially designed roof trusses. From the busbars the outgoing lines run to a steel tower framework outside the switch station, where the choke coils and lightning arresters are placed, as in Figs. 4 and 5. All of the electrical equipment is of General Electric make.

A plan of the generator and switch houses is shown in Fig. 13. Fig. 14 is a side elevation and Fig. 15 is an end section of the buildings. From these a comprehensive idea of the layout of the units, controlling apparatus and electrical equipment is obtainable.

MISCELLANEOUS

It is not the purpose of this article to go into detail regarding the transmission lines leading from the power plant to Atlanta, 89 miles distant, where the largest outdoor substation in the world is located, Fig. 16. From

Atlanta the electrical energy is transmitted over steel tower lines to Lindale, Newnan, Gainesville and Cartersville, at which points are also outdoor types of substations. The transformers at the Atlanta station are water cooled, and the high-tension oil switches are the first of 110,000-volt capacity built for outdoor service. This substation has an ultimate capacity of 60,000 kw. in 110,000- to 11,000-volt transformers. At present there are nine 3333-kv.-a. transformers with a rating of 30,000 kw.

The hydro-electric station at Tallulah Falls is the largest strictly high-head installation in the Eastern half of the United States. It comprises the notable features

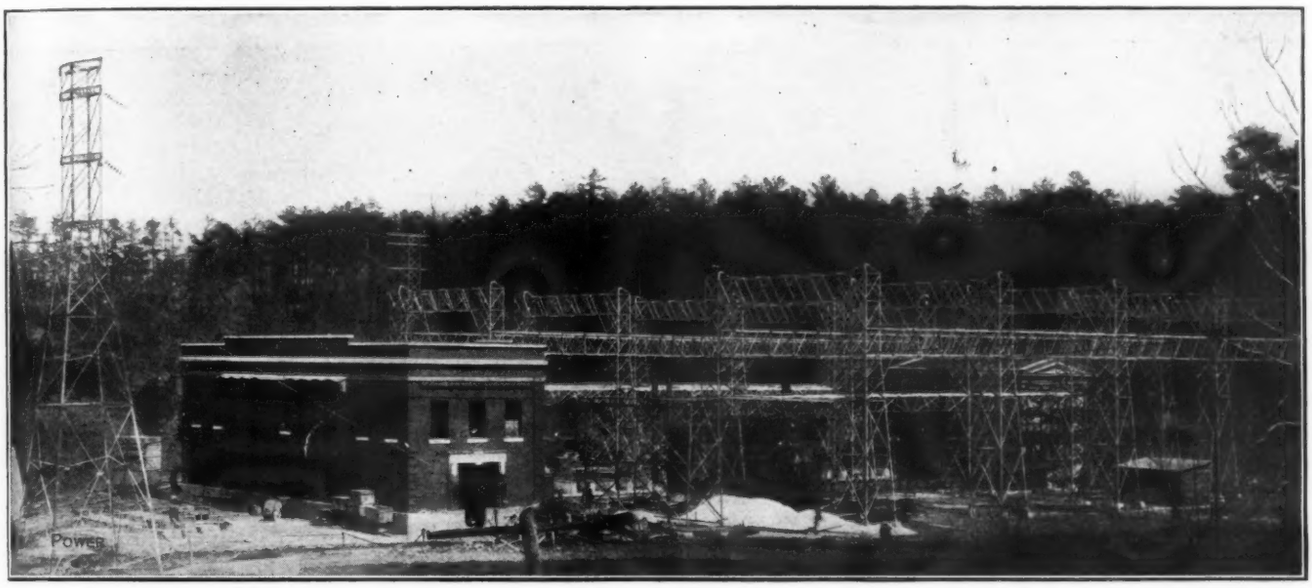


FIG. 16. ATLANTA OUTDOOR SUBSTATION, THE LARGEST IN THE WORLD

of operating under a 600-ft. head using Francis type reaction turbines under the highest head in the South, if not in the country; furthermore, the turbine wheels are among the highest powered in the world. Charles O. Lenz, of New York City, designed and supervised the erection of the entire system, consisting of the main generating plant and auxiliaries at Tallulah Falls; and of the substations and connecting transmission lines.

Benefits from CO_2 Apparatus*

For the purpose of illustration, assume a stack temperature of 550 deg. F., and that air enters the furnace at 85 deg. F. With these conditions, the gases leave the heating surface 465 deg. above the temperature of the entering air. The specific heat of air is 0.24 and that of the gases approximately the same. Having these data, it is possible to get the approximate loss in B.t.u. per pound of gas that goes up the stack. Thus

$$465 \times 0.24 = 111.6 \text{ } B.t.u.$$

is the loss in the present case. The percentage of CO_2 in the gas will tell how many pounds of air is used in burning a pound of carbon. With 18 lb. of air to 1 of carbon, there would be 19 lb. of gases going up the stack per pound of carbon burned, and the CO_2 reading should be about 14 per cent. The loss in B.t.u. would be

$$19 \times 111.6 = 2120.4$$

When the author first began to analyze the flue gases, the best-equipped furnace under his control showed 5 per cent. of CO_2. This indicates 50 lb. of air for each pound of carbon burned. The stack temperature was 550 deg. F. and that of the air entering the furnace 85 deg. F. As previously shown, this means a loss of 111.6 B.t.u. per pound of gas, so that the total loss up the stack per pound of combustible burned will be

$$51 \times 111.6 = 5691.6 \text{ B.t.u.}$$

For best results, there should have been 19 lb. of gas, the 32 lb. excess gas costing practically one-quarter of the fuel.

The boiler was new, and it seemed that there was little room for improvement before the CO_2 apparatus was installed. The foregoing figures only go to prove how deceiving appearances are and how important is the CO_2 instrument.

Finding it difficult to get the fireman to properly regulate the draft, the grate area was reduced to a point where high CO_2 readings could be obtained with the draft full on. Instantaneous readings then showed as high as 14 per cent. CO_2, but the average was about 8 per cent. This low average was caused by the fire-doors being open at the times of firing and cleaning, and often longer than necessary. There were about 60 sq.ft. of heating surface to one of grate area. The temperature of the escaping gases was around 460 deg., and that of the air entering the furnace about 85 deg. The fuel was Arkansas slack and the rate of combustion was about 20 lb. per sq.ft. of grate area.

Between the above temperatures the difference is 375 deg. and the loss in B.t.u. per pound of gas is 90. The CO_2 reading of 8 per cent. indicates that an average of 31 lb. of air per pound of combustible was used. The amount of heat going up the stack is therefore

$$32 \times 90 = 2880 \text{ B.t.u.}$$

Under the first condition the stack loss was 5691 B.t.u. per pound of combustible, and after making the changes the stack loss was 2880 B.t.u., a difference of 2811 B.t.u. Figuring carbon at 14,600 B.t.u. per lb., the saving amounted to 19 per cent.

*Abstract of a paper read by Joseph McCrary before the Practical Refrigerating Engineers' Association, Dallas, Tex.

Sawmill Boiler Explosion at Miley, S. C.

By J. H. Wise

One boiler of a nest of four recently exploded at a sawmill plant at Miley, S. C., wrecking it, as shown in Fig. 1. The boiler was 60 in. in diameter and 16 ft. long, made up of six courses of two sheets each. The plates were $\frac{5}{16}$-in. thick, longitudinal lap joints, double-riveted with $\frac{3}{4}$-in. rivets with a 2-in. pitch; the girth-seam rivets were $\frac{3}{4}$ in., with a $2\frac{1}{16}$-in. pitch. Above the tubes were six diagonal braces from each head to the shell and three through braces. The dome was 30 in. in diameter, 36 in. high, with a $1\frac{3}{4}$-in. cast-iron head. The dome was riveted to the shell with two rows of $\frac{5}{8}$-in. rivets, $2\frac{1}{8}$-in. pitch, and was located over the girth seam between the second and third courses.

An 11x16-in. cast-iron manhole saddle was riveted on the fifth course of the shell with a single row of $\frac{5}{8}$-in. rivets, spaced $2\frac{1}{4}$ in. The opening through the sheet under the manhole saddle was $16\frac{1}{2}$x21 in.; the boiler had 92 three-inch tubes.

The boiler was fired up at 7 a.m. and exploded at about 11 a.m. The front head and the first three courses, remaining intact, passed over two rows of dwelling houses and landed 1190 ft. distant in a field, Fig. 2. All the tubes pulled out of the front head, and one of the through braces went with it. The remaining three courses parted across the sheet through the manhole, were straightened out, and landed, with the back head still attached by four rivets, against the side of the mill building, about 30 ft. away, Fig. 3. A few tubes remained in the back head, but the major part of them were scattered in every direction and over a considerable area, several going more than 500 ft.

The dome—weighing 675 lb., and evidently blown almost directly up—fell about 200 ft. away, rebounded through a shed and landed in an automobile. The condition of the dome indicates that it parted from the boiler first, as the flange is drawn down nearly straight in places. The rivets that held the dome to the shell remain in the sheet except three in the flange of the dome. They show no signs of shear; on the contrary, the shanks of the rivets project from the boiler sheet and the ends were jagged, the fibers standing up, showing that the heads were pushed off.

The rivets at the middle of the girth seam where the boiler parted were all sheared flush with the sheet, indicating that the boiler parted circumferentially at the instant the three rear courses tore across the sheets and through the manhole, as in Fig. 4. The section marked indicates a piece of the plate not yet found.

The adjoining boiler was thrown across a railway track, about 40 ft. distant and, while it had a dent in one side, was not much damaged. The water column and gage-glass remained unbroken.

A negro fireman was leveling the fire under this boiler at the time of the explosion and was blown some distance away, but except for a few slight burns, was uninjured.

Fig. 1. Where the Boiler Exploded

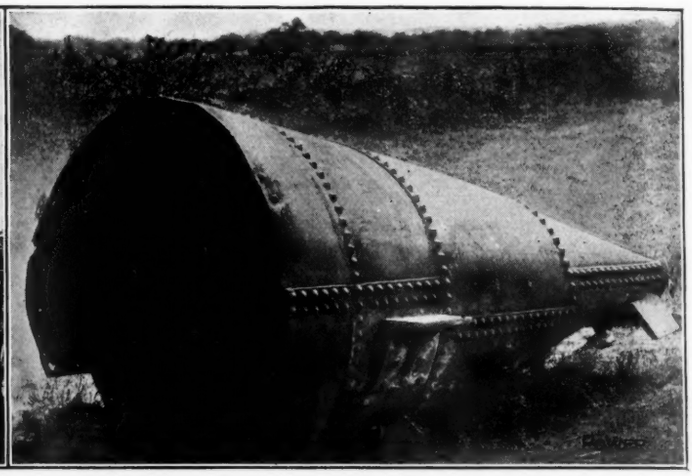


Fig. 2. Part of Boiler That Landed 1190 Ft. Away

Fig. 3. Tubes, Tube Sheet and Torn Boiler Sheet

The only fatality occurred between the boiler shed and mill building, where a negro laborer was literally blown to pieces, as was also the mule he was driving. Why more men were not killed is marvelous as the mill was being operated at the time.

There is none of the usual mystery surrounding this explosion; the boiler had been cut out the day before, and the main stop valve, between the boiler and the safety

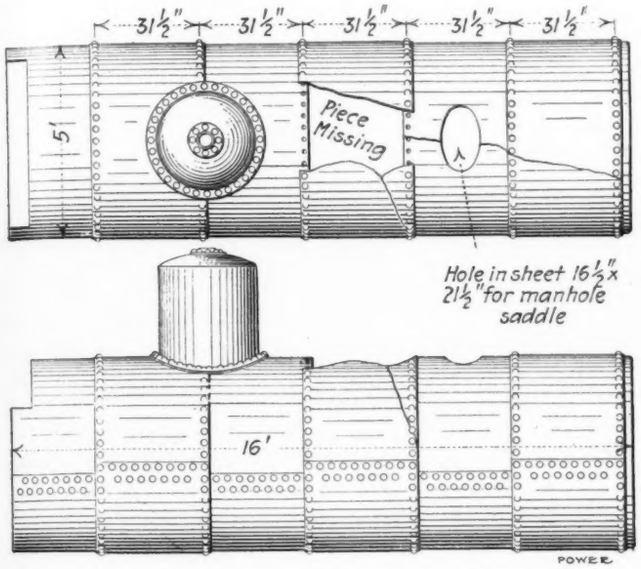


FIG. 4. TORN PORTION OF THE THREE REAR SHEETS

valve, was closed. A mill employee stated that on a previous occasion he had seen 180 lb. pressure on the steam gage, the stop valve being closed. The boiler must have been 25 or 30 years old.

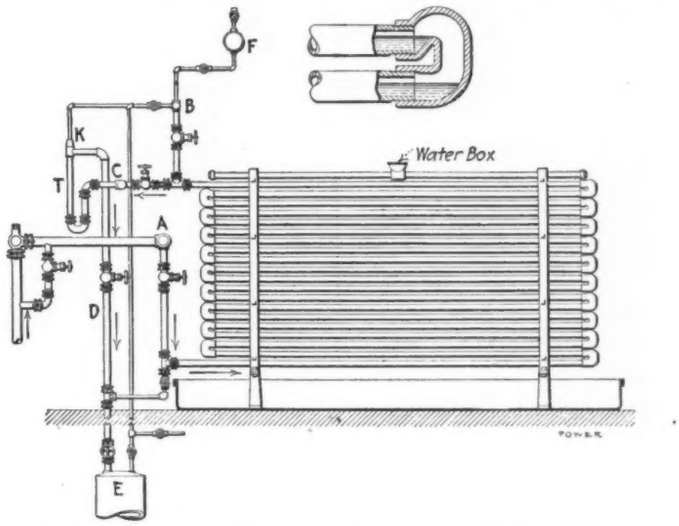
The Block Ammonia Condenser

Although the Block counter-current ammonia condenser has been on the market some little time, it is probably not familiar to all of our readers, and it may be of interest to repeat in part what Mr. Block himself had to say about the condenser at the recent meeting of the Eastern Ice Association in New York City. In general appearance it is like any other type of atmospheric condenser. It is made up of 2-in. pipe, usually 20 ft. long, and is from 16 to 24 pipes high, depending upon the temperature of the water used for condensing purposes. The feature in which the Block condenser differs from any other atmospheric condenser is that the liquid ammonia produced is for a time held in the pipes for the purpose of serving as a heat-transferring medium. The vapor enters the lowest pipe of the condenser, begins to condense as soon as the superheat is removed, usually in the third pipe from the bottom. The liquid ammonia now intermingles with the vapor and it travels forward and upward together at high velocity. As the vapor in the form of globules enters the liquid, each globule is surrounded by liquid and is itself condensing surface, giving up its heat to the liquid. The liquid in turn gives up its heat to the pipe through which it passes, and thus to the water flowing over the pipe. In the lower pipes there is much vapor and little liquid, but the proportion of liquid increases as the mixture travels forward, until finally all the vapor is condensed. A farther difference is that the condenser is a true counter-current apparatus, while other condensers are built on the parallel-flow principle.

The heat transfer from a gas through metal surfaces to a liquid is approximately at the rate of 60 B.t.u. per sq.ft. of surface per degree difference of temperature per hour, while the transfer of heat from a liquid to a liquid through metal surfaces is about 300 B.t.u. under the same conditions. The transfer from a mixture of vapor and liquid, such as is present in the Block condenser, to water flowing over the outer surfaces of the pipes is at the rate of from 180 to 200 B.t.u. per sq.ft. of surface per degree difference of temperature per hour. This explains why the Block condenser is from three to four times as effective as the ordinary type.

As the circulation of the ammonia is from the bottom of the condenser toward the top, the liquid ammonia leaves the condenser where the water is coldest and must therefore be cold itself. This is an important point when it is considered that liquid ammonia before evaporating in brine-cooling or direct-expansion coils, must first cool itself down to the temperature at which it evaporates.

Take the case of a refrigerating machine operating at 15 lb. back pressure, which is equivalent to a temperature of about zero Fahrenheit in the evaporating or brine-cooling coils. Assume that the temperature of the liquid ammonia coming from the condenser is 100 deg. F., then it is evident that the liquid must first be cooled down to the temperature of zero before it can begin to do effective cooling work. To bring about the cooling of the liquid, part of it must evaporate for that purpose only, and of the 572 B.t.u. of latent heat per pound of liquid there remains only 472 available for effective cooling work. The loss is nearly 18 per cent. If the liquid leaves the condenser at 70 deg. and is cooled down to zero, it will require only 70 B.t.u. for this purpose, and practically 500 B.t.u. will be available for effective cooling work, the loss in this case being a trifle over 12 per cent., making a net gain of 6 per cent. It is thus apparent that a machine making 100 tons of ice in 24 hr. under the first



BLOCK COUNTER-CURRENT AMMONIA CONDENSER

condition would make 106 tons of ice in the same period of time under the second condition without adding to the cost of operation.

It might be supposed that a certain effort would be necessary to push the liquid produced in the condenser

upward through all the pipes and return bends, and thus increase the condensing pressure. This, however, is not the case, as the following explanation by Mr. Block will show.

Assume the water temperature as it flows on the upward pipe of the condenser to be 70 deg. F., and the temperature of the water leaving the lowest pipe of the condenser to be 85 deg. F. The pressure within the upper pipe will therefore be that due to a temperature of 70 + 10 = 80 deg. F., the difference of 10 deg. between the temperature inside of the pipe and the temperature outside being the usual allowance. The ammonia pressure due to a temperature of 80 deg. F. is 139.2 lb.

Within the lowest pipe of the condenser the temperature will be 85 + 10 = 95 deg., corresponding to a pressure of 182.6 lb. The difference therefore between the pressure in the upper and lowest pipe of the condenser is 43.4 lb. This pressure is quite sufficient to induce the mixture contained in the condenser pipes to travel forward and upward in spite of the friction which must be overcome, without any extra effort on the part of the compressor. As a matter of fact the friction absorbs nearly all of this excess pressure. In practice it has been found that a slight difference in pressure exists between the upper and lower pipes; a difference of as much as 3 lb. has been observed by Mr. Block.

In the accompanying drawing of the condenser, *A* is the hot-gas header from which the gas, or rather vapor, travels downward and enters the bottom of the condenser. It then travels back and forth and upward, and when it reaches the second or third pipe from the top all of it has been converted into liquid, which leaves the condenser through the top pipe and enters the liquid header *C*. The liquid flows through trap *T* and down pipe *D* to the liquid receiver *E*, the trap being inserted for the purpose of preventing the accidental discharge of unliquefied vapor, due to a momentary interruption of the water supply or for other reasons. At *B* is the equalizing header, which is connected to every coil of the condenser, and *K* is a siphon-breaker on top of trap *T*, which connects with the equalizing header *E* and prevents the discharge of the liquid in jerks, thus insuring a uniform flow. An air drum *F* is also connected with the equalizing header. Air and noncondensable gases will automatically collect in this drum, and if it is desired to purge the condenser occasionally it can be done during operation.

To do three times as much work with one of these condensers as with another type, it is necessary to supply three times as much water. The Block condenser does not require less water than any other to do a stated amount of refrigerating work, nor does it require more water. If 150 gal. of water per minute are charged over seven or eight condensers of the ordinary type in order to condense all the vapor discharged by a 100-ton refrigerating machine, then it will require 150 gal. of water per minute to do the same amount of work with three Block condensers, the difference being that the water heretofore distributed over the seven or eight coils of the ordinary type must now be distributed over three coils of the Block type.

Plant vs. Purchased Power in Department Store

By F. W. Rose*

SYNOPSIS—Complete power-plant costs of a large department store affording an actual comparison between the costs with central-station service and a private plant which was later installed.

The Emporium department store, of St. Paul, Minn., is a four-story and basement fireproof building, having a cubical content of 1,950,100 cu.ft., and a floor area of 125,000 sq.ft. The heating is mainly by direct radiation, a one-pipe gravity system with a Paul air line being employed.

The basement and first floor have a ventilating system in addition to the heating system, consisting of two steel-plate fans, each having a capacity of 35,200 cu.ft. per min. The two fans are driven by a 10x12-in. horizontal, center-crank engine. In the tempering coils there are 2272 sq.ft. of radiation, and in the heating coils 3040 sq.ft. The air is drawn through an air washer having a capacity of 75,000 cu.ft. per min.

When the building was built in 1909 a boiler plant was installed and provisions were made for a generating plant which was put in service one year later. The boiler plant consists of three 200-hp. water-tube boilers with Murphy stokers, duplicate boiler-feed pumps, open feed-water heater and the usual auxiliary equipment. The building has its own water supply, consisting of a steam pump which takes water from a deep well and delivers it to a pressure system.

The generating plant consists of a 100-kw. and a 200-kw., 250-volt, three-wire, direct-current units, driven by side-crank, tandem-compound, noncondensing engines. These were put in operation in September, 1910, which was the expiration of the contract for central-station service. In the summer of the following year a contract was made with the central-station company for emergency service and night lighting, which has been in force ever since.

TABLE I. POWER-PLANT COSTS—1909–1910

Month 1909	Cost of Purchased Current	Kilowatt Hours Generated	Cost of Coal	Loads of Ash	Cost Miscellaneous Supplies	Labor Cost	Total Monthly Cost
Sept.	$1050.00	.....	$136.71	....	$12.00	$225.00	$1423.71
Oct.	1050.00	.....	142.68	....	14.00	225.00	1431.68
Nov.	1050.00	.....	398.97	....	13.50	225.00	1687.47
Dec.	1050.00	.....	950.60	....	12.00	225.00	2237.60
1910							
Jan.	1050.00	.....	668.41	....	10.00	225.00	1953.41
Feb.	1050.00	.....	406.41	....	10.00	225.00	1691.41
Mar.	1050.00	.....	414.81	....	10.00	225.00	1699.81
Apr.	1050.00	.....	163.70	....	10.00	225.00	1448.70
May	1050.00	.....	247.69	....	11.25	225.00	1533.94
June	1050.00	.....	274.80	....	11.25	225.00	1561.05
July	1050.00	.....	239.64	....	10.00	225.00	1524.64
Aug.	1050.00	.....	174.57	....	11.00	225.00	1460.57

In September, 1912, an addition to the store was opened to the public. The cubical content of this addition is 1,316,470 cu.ft. and the floor area is 85,440 sq.ft., giving

*Consulting engineer, Minneapolis, Minn.

a total of 3,266,600 cu.ft. and 210,440 sq.ft. respectively, which is an increase of 67 per cent. No change was required in either the boiler or generating plant to take care of this addition and there is capacity for still further extension.

At present there are 21 motors in the store, having a total rating of 193 hp. Six of these are on passenger elevators, one on a freight elevator and one on an escalator.

Very accurate records have been kept and the data in the tables were taken from these records. Tables 1 and 2 show respectively the costs for the first year, 1909-1910, when central-station service was employed exclusively, and 1912-1913 when using the private plant with purchased current for night lighting. Table 3 gives a comparison of costs for the four years that the store has been in use.

TABLE II. POWER-PLANT COSTS—1912–1913

Month 1912	Cost of Purchased Current	Kilowatt Hours Generated	Cost of Coal	Loads of Ash	Cost Miscellaneous Supplies	Labor Cost	Total Monthly Cost
Sept.	$150.48	23,460	$552.53	15	$5.06	$332.66	$1040.73
Oct.	112.31	28,580	462.42	19	17.85	392.66	985.24
Nov.	122.88	31,660	748.55	18	34.10	392.66	1298.19
Dec.	106.32	41,200	433.54	24	33.10	382.66	955.62
1913							
Jan.	50.88	42,400	639.18	28	22.21	414.00	1126.27
Feb.	36.00	38,030	1049.64	23	18.60	414.33	1518.57
Mar.	66.48	35,630	850.92	25	51.55	386.33	1355.28
Apr.	105.60	30,530	385.02	20	8.38	359.33	858.33
May	106.32	31,000	320.85	24	37.73	359.33	834.23
June	108.24	26,200	683.15	18	22.70	353.33	1167.42
July	94.32	24,190	215.51	18	14.60	353.33	677.76
Aug.	100.08	25,450	503.28	16	24.00	353.33	980.69

The ash is removed by the company's teams and no charge is made, but in figuring these costs an allowance of 50c. per load was made, as a record of the number of loads has been kept for each year except the first, and for the first year the cost of removal of ash was taken as the same percentage of the cost of coal as in the other three years.

The lost rent charged against the space taken up by the plant was figured at 30c. per sq.ft. per year. Interest, depreciation, taxes, etc., were figured at 12 per cent. on the plant investment and 6 per cent. on the added cost of the building on account of the plant.

It is interesting that the total costs for the last year, with the 67 per cent. increase in the store space, are less than any of the preceding years, and much less than the first year when central-station service was used. This is accounted for in a very large measure by the careful watch kept by the chief engineer, W. G. Lyon, for all opportunities of reducing the cost of operation without impairing the efficiency of the results, and by the larger load factor on the plant which results in higher efficiency. This is especially true of the boiler plant, as only one boiler has ever been used at one time even with the increased building. Another thing which has reduced the costs was the changing of lamps. When the store was first opened, a large number of arc lamps which had been used in the old store were installed. These lamps have all been replaced by large tungstens, carbon lamps have been replaced by tungstens and in places where smaller lamps would give satisfactory results, the smaller lamps have been used.

Compressed-Air Starters

By A. L. Brennan, Jr.

During the experimental stages of self-starters, compressed air was used extensively and proved entirely reliable; but designers soon found that along practical lines it was adapted only to heavy power units. This was principally because on motor cars and boats the space available is often limited and since the first requirement of a mechanical or functional self-starter is compactness, this condition could not always be had when using a system that is not self-contained.

The component parts of a compressed-air system consist of a valve mechanism or distributor for controlling the air to the cylinders, suitable piping, air compressor, and storage tank for air. A tank holding air sufficient to start even a small multicylinder motor several times without recharging must be of fair size and consequently takes up considerable room. Some argue that a tank holding sufficient air to start the motor once is sufficient. This is poor practice, for, unless the tank is of sufficient volume to start the motor several times without recharging, any one of the several complications liable to take place when starting will render the self-starter inoperative. Little difficulty is encountered when installing this type of self-starter in stationary plants for the room required for suitable storage tanks is usually a secondary consideration.

TABLE III. POWER-PLANT COSTS FOR FOUR YEARS

Year	Cost of Purchased Current	Kilowatt Hours Generated	Cost of Coal	Cost of Ash Removal	Cost of Miscellaneous Supplies	Labor Cost	Lost Rent, Interest, Depreciation, Taxes, etc.	Total Costs	Cost Less Purchased Current	Cost per Cubic Foot	Cost per Square Foot
1909 and 1910	$12,600.00	.....	$4,218.99	$76.79	$135.00	$2700.00	$2835.00	$22,565.78	$9,965.78	1.157 cents	18.05 cents
1910 and 1911	498.08	336,110	11,638.90	198.50	422.45	4284.00	4785.00	21,826.83	21,328.85	1.119 cents	17.46 cents
1911 and 1912	1,694.60	389,569	7,405.73	149.50	304 38	4110.58	4785.00	*17,786.94	16,092.34	0.912 cents	14.23 cents
1912 and 1913	1,159.91	378,330	6,854.59	124.00	289.88	4493.95	4785.00	17,717.33	16,547.42	0.542 cents	8.41 cents

* Net cost after deducting $662.85 representing charge for steam, water, electricity and labor use during construction work on addition to building.

The first cost of a compressed-air system is usually low and the operating and maintenance cost is small; also it requires little attention. In regard to the correct installation of such a system the following suggestion will be found of value.

Instead of using one large tank for the storage of the compressed air, two tanks should be used, one large and one small, fitted with suitable piping and valves to regulate the admission and release of air from either or both tanks. This will allow the compressor to feed air to either or both tanks and the small tank can be held for emergency purposes. A hand pump should be connected to the small tank, thus affording an auxiliary pumping system. If the joints are made up well with shellac and suitable valves are placed at the tanks, the air pressure should remain almost indefinitely.

Some air-starting mechanisms are controlled by a distributor which operates on the same principle as a timer which governs the flow of electricity to a spark plug. This method has proved entirely satisfactory and is to be found on several motors of various sizes. On other engines the direct-valve system is employed, the valves being controlled by a shaft which, when shifted, engages with the inlet compressed-air valve stems and causes the valve to open and admit compressed air to the cylinder last under compression, thus forcing the piston down, since both intake and exhaust valves are closed. The air valve is closed when the piston reaches the bottom center of the stroke and a similar set of operations take place in the next cylinder in the order of firing. The

same operations take place in connection with a distributor starter, the only difference being that the air is admitted by the distributor "uncovering" instead of a valve opening.

Since both inlet and exhaust valves are closed during the admission of the compressed air, the efficiency of the mixture is not impaired for the reason that the air is not admitted to the cylinders until the pistons have passed the point of firing. The "direct valve" method appears to hold favor on large motors, although it must not be conceded from this that the disk distributing valve is not dependable.

The chief difficulty encountered with automatic air-starters is attributable to loss of pressure which in turn can be traced to poor check valves, faulty joints in the pipe line, distributor or valves leaking, worn or scored compressor cylinder, or the compressor piston or rings worn or broken.

Air leaks are usually easy to trace if undertaken in a systematic way. The writer has found an old shaving brush and a piece of shaving soap convenient for locating leaks of this nature. By painting the joints of the pipe line and other parts likely to leak with soap suds, a leak is easily detected and in fact very slight leaks can be found in this way which would otherwise go unnoticed. Care should be exercised when making up joints that the pipe fittings take hold for at least four or five threads. Shellac is undoubtedly the best medium to use for all air-line joints and should be applied evenly to both sets of threads and the joint set up firmly at once. Joints so treated will stand vibration without leaking.

Grinding is about the only positive remedy for a leaking valve. Valve grinding may be considered an art in itself, but the novice can get good results by following a few simple rules: Never attempt to grind a valve without first removing its "seating" spring for otherwise both the valve face and its seat are likely to be deeply scored. Never grind a valve by revolving it one way, but alternate, revolving the valve two or three times in one direction and then two or three times in the opposite direction. When changing the direction of rotation, lift the valve from its seat, turn a quarter and again seat, this will cause other particles of the abrasive to cut and prevent scoring or cutting in one place. Never use a dry abrasive except the very fine powders for finishing. Grinding is greatly facilitated by playing a spring under the valve head that will cause the valve to leave its seat when relieved of the pressure exerted when grinding. The valve should be ground against its seat until both have a bright even surface which will insure an air-tight union.

Starting troubles which prevent a gas engine from picking up its cycle when hand cranking is employed will likewise result in a non-start of motors fitted with self-cranking devices, therefore, if a motor is turned over by an auxiliary means and does not start within thirty seconds,this is, usually, a positive indication of existing trouble.

Big Western Development—The Stone & Webster Corporation, Boston, Mass., has a representative in Seattle, Wash., completing arrangements for starting work on the development of 85,000 hp. for the operation of electric car lines and power purposes. The company recently acquired rights to the Skagit and Cascade rivers and their tributaries. Plans are being completed in the company's Eastern office and will be ready for starting of work the first part of the year. The development will cost about $6,000,000.

Instruction in Refrigeration

By J. S. A. Johnson*

The writer was greatly interested in a Power editorial of Oct. 28, 1913, in which an appeal was made to engineering schools to offer thorough courses in refrigeration.

In the course in mechanical engineering at the Virginia Polytechnic Institute, three class periods per week for one term are devoted to refrigeration, while the theory of the subject is covered in thermodynamics. In addition to the class work, a laboratory course is given which includes the testing of compression and absorption plants.

The quantities of brine, cooling and condensing water, coal, steam, electrical and mechanical work, and temperatures of brine, ammonia and water, are obtained in the usual manner, by weighing or measuring. The quantity of anhydrous ammonia is got by the use of two accurately calibrated measuring receivers, provided with gage-glasses having graduated scales, and connected in a by-pass to the main anhydrous ammonia line. While one

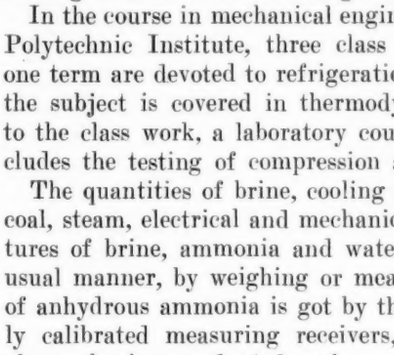


Fig. 1

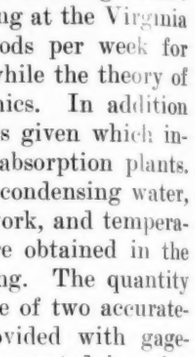


Fig. 2

Fig. 1. Receivers of Compression Plant

Fig. 2. Absorption Plant Receiver

receiver is filling, the other is being emptied. A correction has to be made in the apparent volumes of anhydrous ammonia consumed on account of the vapor generated (in the receiver which is being emptied) from the liquid which was in that receiver after the closing of the inlet valve. For instance, when receiver No. 1, Fig. 1, is emptied of liquid from level A to level B, the actual weight of liquid leaving the vessel will be

$$(W_1 \times V) - (W_2 \times V)$$

in which expression, W_1 is the specific weight of the anhydrous ammonia (liquid) at the given pressure, W_2 the specific weight of saturated vapor at the same pressure and V the volume included between the levels A and B. From calibration curves, the total volumes used in a test may be determined.

The compressor is of the vertical, two-cylinder, single-acting, belt-driven type. The cylinders are tapped and provided with special valves for the attachment of indicators so that the clearance will be a minimum while diagrams are being taken.

The quantity of anhydrous ammonia used in the absorption plant is calculated from observations on the total weight of strong liquor circulated, and the percentage strengths of the weak and the strong liquors. A cooling coil is provided for sampling the weak liquor, the temperature of both weak and strong liquors being reduced to 60 deg. F.

*Professor of experimental engineering.

As a check on this method, observations are also made on the main ammonia receiver (in the absence of the two auxiliary measuring receivers) which stands vertically, and is provided with a gage-glass and graduated scale. Referring to Fig. 2, the level of the ammonia being at A at the beginning of the test, and a constant flow of ammonia from the condenser being maintained, the valve V (not the expansion valve, which is kept at constant opening) is opened, and the level of ammonia will drop to B in time t_1. After valve V is closed (level at B) the receiver will fill to level C in time t_2. If V_c represents the volume of ammonia between B and C, the quantity of ammonia generated in time t_1, while the receiver was emptying from A to B, will be very nearly equal to

$$\frac{V_c}{t_2} \times t_1$$

Or, letting the odd subscripts refer to times of emptying, and the even to filling, the quantity of ammonia generated during a given period of emptying will be

$$\tfrac{1}{2}\left(\frac{V'}{t_n} + \frac{V''}{t_{n+2}}\right) t_{n+1}$$

n being an even number and the corresponding time interval being a period of filling. By adding these amounts to the amount apparently discharged while emptying, the total volume of ammonia generated during the test may be ascertained with possibly greater accuracy than by a calculation involving the total weight of strong liquor circulated.

The weight of steam consumed in the still, or generator, is measured after discharge through a trap and cooling coil.

From the absorption plant, the ammonia liquid (anhydrous) is conveyed several thousand feet to the rooms to be refrigerated, while in the compression plant the transmission line is comparatively short.

Both plants afford excellent opportunities to the students for testing and observation, and the course in refrigeration meets with much favor.

Solving the Cinder Problem at Waterside--I

By Charles H. Bromley

SYNOPSIS—Being the first of a series of articles treating of the apparatus and methods used to catch the cinders in the flue gases at Waterside stations Nos. 1 and 2 of the New York Edison Co., New York City. The problem extends back over a number of years and various experts have worked on it. The first scheme was to precipitate the cinders by reducing the velocity of the gases, but this proved futile. Next, settling chambers, baffles, screens, water sprays, etc., were tried. Finally, high gas velocity with sharp changes in direction of flow and impingement on films and surfaces of water proved successful. A special cinder-producing plant was erected to try out various cinder-catching apparatus. This series of articles deals with the evolution of the cinder problem at Waterside, describes the various apparatus used and the conditions met, the purpose being to show what are and are not successful apparatus and methods so as to point out the strong and weak points in cinder elimination, and show what apparatus may work successfully in ordinary plants where the coal consumption is much less than at Waterside.

Difficulty of Solving the Cinder Problem

Suppose you had all the money you needed to hire experts, to erect flues with numerous kinds of baffles, water sprays, fans—to even erect a special cinder-producing

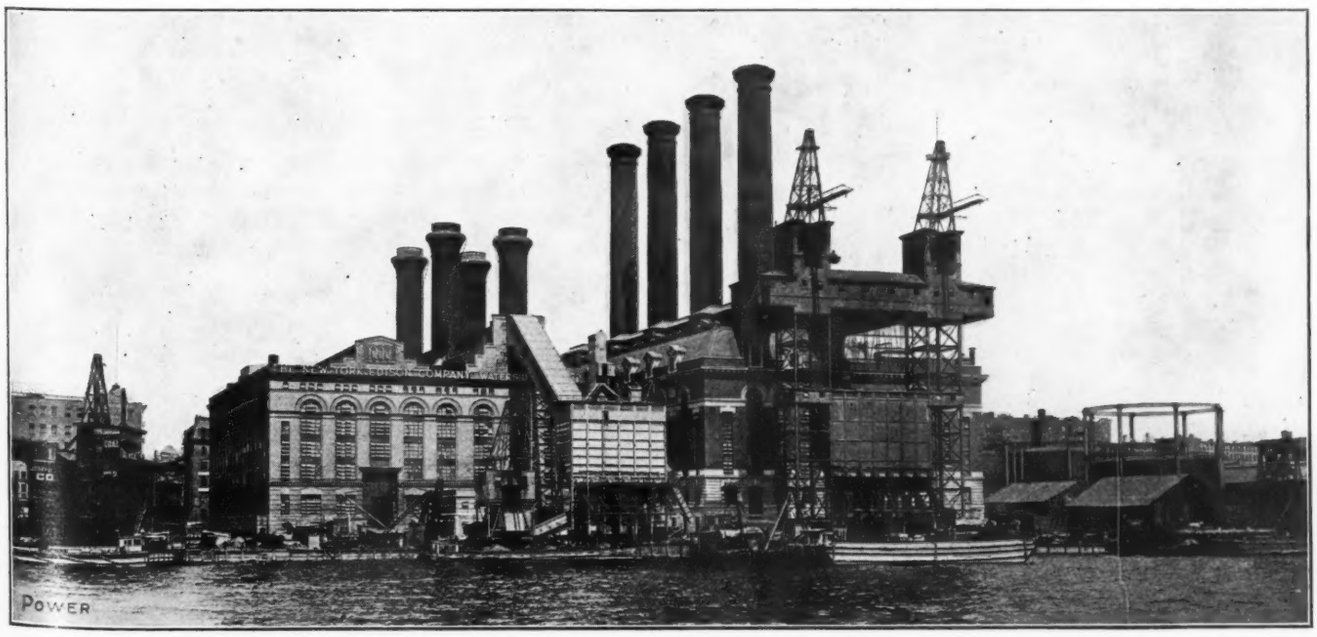


Fig. 1. The Waterside Stations of the New York Edison Company

plant to try out apparatus, in fact, suppose you had all the resources imaginable to enable you to take cinders out of smoke. Easy! You would conclude that you had the greatest "cinch" of the age. But you would not. The New York Edison Co. had and has all those things and has spent years in trying to solve the problem and knows.

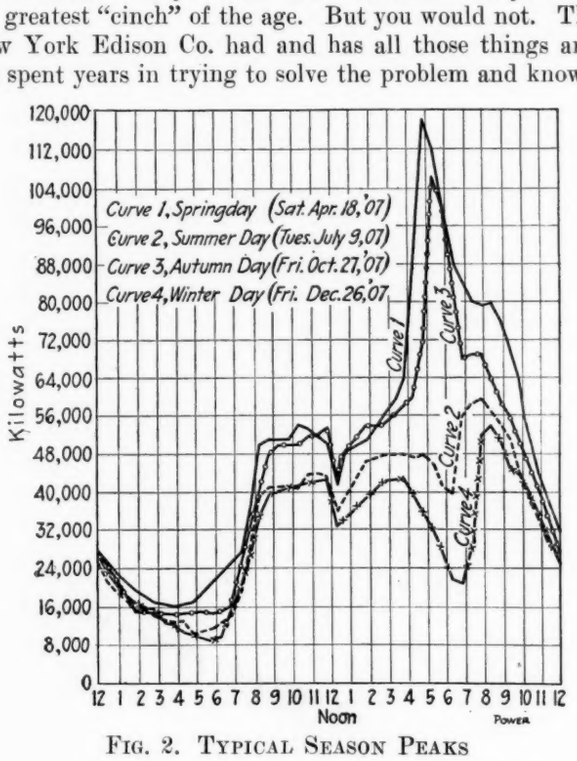


FIG. 2. TYPICAL SEASON PEAKS

Numerous experts have exercised their skill and talent on the problem and have failed.

The Edison company's engineers have finally developed a successful cinder-catching apparatus which will be described in this series. The present article deals with conditions as they existed during the growth of the cinder nuisance.

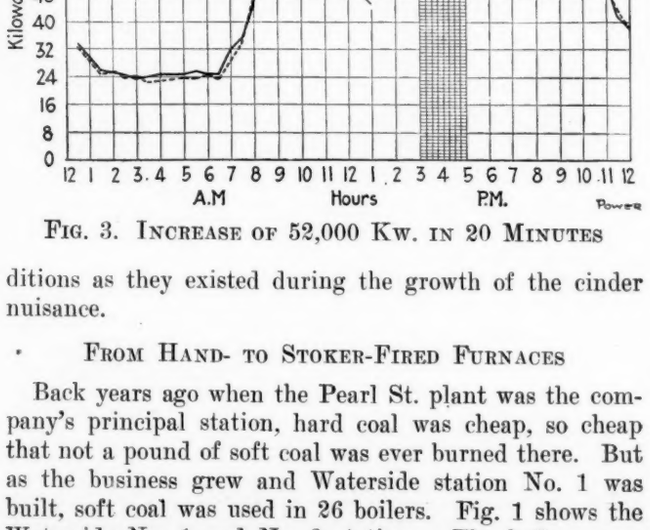


FIG. 3. INCREASE OF 52,000 KW. IN 20 MINUTES

FROM HAND- TO STOKER-FIRED FURNACES

Back years ago when the Pearl St. plant was the company's principal station, hard coal was cheap, so cheap that not a pound of soft coal was ever burned there. But as the business grew and Waterside station No. 1 was built, soft coal was used in 26 boilers. Fig. 1 shows the Waterside No. 1 and No. 2 stations. The boilers were equipped with stokers which the manufacturers guaranteed would meet the load conditions and produce practically smokeless combustion. Despite this guarantee the smoke complaint became so serious that neither the engineers for the stoker makers nor the Edison engineers could stop or reduce it.

BACK TO HAND FIRING

The stokers were discarded and the company went back to hand firing, burning No. 3 buckwheat coal on stationary grates, a practice not uncommon where smoke ordinances are enforced. While the use of hard coal eliminated the smoke trouble, yet its use resulted in new difficulties, owing to the production of cinders.

A NEW STOKER IS DEVELOPED

At this time a now well known stoker was in its experimental stage, and the Edison company believed it could develop it to meet its needs and thus end the cinder evil by burning a mixture of hard and soft coal. This was done and the stokers installed in reconstructed furnaces with special arches. Owing to rapid increase in coal consumption, due to a continuously growing load, the trouble became greater instead of diminishing.

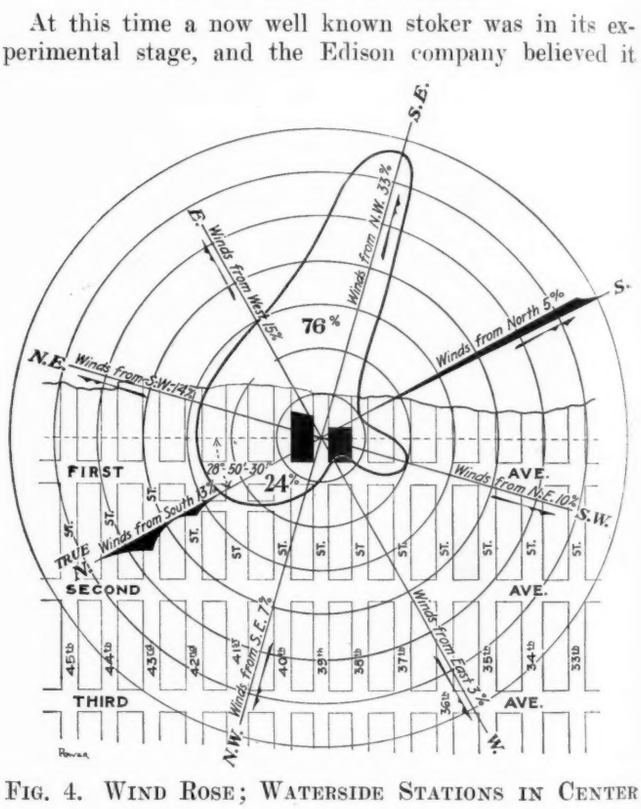


FIG. 4. WIND ROSE; WATERSIDE STATIONS IN CENTER

LOAD INCREASES 52,000 KW. IN 20 MINUTES

An idea of the load conditions is gained from the load curves for the different seasons, as shown in Fig. 2. Note that the curve for Apr. 18, 1907, shows a rise of 54,000 kw. in one hour, which means that the fires under the standby boilers were suddenly disturbed, the draft increased and the production of cinder made much greater as a result. Not long ago these Waterside stations took on nearly 52,000 kw. in 20 min., due to a sudden shower increasing the demand. Fig. 3 shows this curve contrasted with a normal day curve. And so these peaks come and go, and make the smoke and cinder problem difficult of solution.

Fig. 4 is a wind rose, showing the directions and duration in time of winds, and the distribution of cinder. The Waterside stations are in the center, and the clear open space above the irregular horizontal line represents the East River. The prevailing winds are northwest, coming from that direction 33 per cent. of the time. West winds are next highest, blowing for 15 per cent. of the time.

The rose also shows that 76 per cent. of the cinder emitted from the stacks is blown into the river, due to the prevailing winds from the northwest. The other portion represents the area within which the remaining 24 per cent. of the cinder was distributed. This rose shows that less than one-quarter of the cinder emitted was deposited in an area from which complaints came. This fact indicates what a large amount was blown from the stacks, when less than one-quarter of it caused the protests that have been made. It is from a study of this wind rose, perhaps, that one can best appreciate how serious this cinder problem really is, or rather was; since a successful catcher has been devised.

Next week's article will describe the boiler and flue arrangement at Waterside and illustrate the settling chambers and some of the apparatus used and will tell why it failed.

The Diesel Engine in Marine Service

Georges Carels, the well known Diesel-engine builder, in an address before the North-East Coast Institution of Engineers and Shipbuilders,* gave a sane and most comprehensive review of Diesel-engine practice as now applied to marine work.

Admitting that the progress of the Diesel engine in this field has been slow, he attributed this partly to the high price of oil and partly to a reaction from the extreme optimism of the Continental press, most owners of vessels preferring to wait and observe the experience of those motor ships now in service rather than join the pioneers.

He strongly condemned the practice of some firms in attempting to put Diesel engines on the market without extensive preliminary tests backed up by the necessary experimental work. As a result of this, many troubles have developed, but these, he believed, served a useful purpose in showing how not to build Diesel engines.

The demand a few years ago for light-weight, high-speed engines was productive of a great variety of designs, in many cases unreliable, and the present tendency is to revert to slower speeds and to fewer types.

Regarding the relative merits of the two-stroke and four-stroke cycles, Mr. Carels had this to say, first considering the high-speed types:

1. The two-stroke-cycle engine is safer because it has no exhaust valves.

2. The reversing gear with the two-stroke cycle is simpler.

3. Comparing engines of the same power and the same number of cylinders, the two-stroke-cycle engine has the more uniform turning moment.

4. The mean temperature is higher in the two-stroke cycle.

5. It consumes more fuel and lubricating oil than the four-stroke-cycle engine.

6. Its mean effective pressure is lower; therefore, a high-speed, two-stroke-cycle engine is not necessarily lighter than a high-speed, four-stroke cycle.

Comparing slow-speed engines of both cycles reverses the case. Here it is possible to obtain a mean effective pressure equal to or higher than that of the four-stroke cycle, therefore, the slow-speed, two-stroke-cycle engine can be made lighter and cheaper than the four-stroke-cycle engine of the same power and speed. The fuel consumption is, in the former, a function of the speed of the engine. At slow speed it is only about 10 per cent. higher than in the corresponding four-stroke-cycle engine; the same remark applies approximately to the lubricating-oil consumption. Points (1), (2), (3) and (4) still apply.

With regard to slow-speed, two-stroke-cycle engines with scavenging valves and those having ports, Mr. Carels pointed out that, although the latter have the advantage of greater simplicity, the scavenging is less perfect. These features were thus summarized.

In all cases where simplicity and robustness, combined with maximum reliability, are the essential factors, and where the fuel bill is of secondary importance, the valveless two-stroke-cycle is recommended. In those where the fuel economy is the essential factor, but high speeds are necessary because of space and weight limitations, the four-stroke-cycle engine is preferable; this applies to electric-lighting sets for ships, etc. For all high-powered, slow-speed engines for land and marine purposes—say, from 1000 hp. upward—the two-stroke-cycle engine is to be preferred. This is the real domain of the two-stroke-cycle engine, where its advantages can be fully brought out.

Taking up features of design, Mr. Carels emphasized the necessity for considering not only direct transmission of forces, but also those due to expansion in all parts subject to high temperatures—a fact which makes the problem much more complex than in the case of the steam engine. Due to the high transmission of heat through the walls of the combustion chamber, only special grades of cast iron are suitable for these parts, and it is highly desirable that more extensive study be given to the question of appropriate cast irons for this service. All such parts should be very accurately machined, the clearances exactly determined and the relative degree of wear closely followed.

Of pistons, Mr. Carels expressed preference for the crosshead type rather than the trunk type, because the latter is called upon to fulfill the double requirement of taking the side pressure of the connecting-rod and yet remaining gas-tight. While trunk pistons have been used successfully in many medium-sized engines, cases of gripping have nevertheless occurred from time to time.

A part that needs careful attention is the fuel valve. Not only should the needle and valve seat be removable in a minimum time, but this should not make resetting of the valve-gear afterward necessary. Consideration should be given to the influence of expansion of the needle and valve-gear on the timing and the design should be such as to avoid sticking of the needle. Also the starting valve should be so designed that it cannot rust in its casing. Sticking of the starting valve has frequently given rise to trouble.

*For a complete report of this paper see "The Engineer," Dec. 5, 1913.

In this connection, the speaker suggested that some means be provided for grinding the valve on its seat from time to time while the engine is running.

As to the frequent capriciousness of fuel pumps, Mr. Carels laid down the features that should be followed. Air pockets should be absolutely avoided; valves should not be given too broad a seat; the fuel must be very finely filtered, and the fuel pipe from the pump to the fuel valve must be as short as possible. In marine engines, as the possible reduction of the number of revolutions at slow speed is largely dependent on the same amount of oil being given to all cylinders, there should be a separate plunger for each cylinder and not a fuel distributor. Here also the suction and discharge valves should be easily removed and replaced.

In Mr. Carels' opinion, many made the mistake of oiling their compressors too profusely, or allowing too much to enter the compressor cylinders, and then providing insufficient or no means of separating that oil after each stage of compression; also in not sufficiently intercooling the air. The air must be cooled immediately after the discharge valve of each stage. Long, uncooled pipe strains between the compressor and the cooler should always be avoided and the receivers should be large. It must not be forgotten in calculating a compressor that the air in each stage must reach a pressure considerably higher than the receiver pressure to open the valves, and the number of stages must be so chosen that the final temperatures shall not be high enough to cause ignition of the oil vapors carried in the air.

On the other hand, safety valves should be placed immediately after the discharge valves and not at the coolers or receivers, because an explosion propagating in a long pipe produces a local rise in pressure sufficient to blow it up long before the explosion wave reaches a safety valve placed further on.

The air bottles should be provided with sufficient drainage conveniently located, the best method being to provide a continuous blowoff.

One more important point taken up was the crankshaft, which should have a high factor of safety, the diameter being about 0.6 that of the cylinder. A short, stiff crank withstands torsional stresses best and the bearings should be preferably short.

Hot-Water Boilers vs. Live-Steam Heaters

The reply by Ira N. Evans to the following question of a reader in England may be of general interest.

"In POWER of July 18, 1911, I. N. Evans states that it is very difficult to regulate the fire under hot-water boilers on account of the wide variation of the outside temperatures. Do I understand this occurs if temperature-controlled dampers are used? I should like to see an opinion of an authority like Mr. Evans if he considers it more economical to utilize, say, three existing Lancashire boilers for heating approximately 60,000 sq.ft. of radiation and circulate the water in series through exhaust-heated closed heaters and then through the necessary number of Lancashire boilers to add the extra heat required, or to utilize the boilers as steam producers and install the necessary live-steam closed heaters."

Using hot-water boilers on a system of heating using forced circulation rather than a live-steam heater is a question of investment and number of fires necessary rather than one of economical transfer of heat from the fuel.

In case a live-steam heater is used and the steam circuit broken between the heater and boiler, either by drain traps or pump and receiver, a loss of 10 to 15 per cent. is possible. Where a gravity return is maintained or the circuit sealed the live-steam heater arrangement should prove the more economical.

When power and heating are required, if both hot-water and steam boilers are used, reserve capacity of both types has to be maintained for each branch of the service. If all of the boilers generated steam at the same pressure they would be interchangeable and there would be less liability of putting extra units in commission to handle the peaks of both branches of the service. If the power and heating were balanced during the peak power load, exhaust steam would be available for heating the balance of the time, and when the exhaust was insufficient the same boilers could supply the live-steam heater. Hot-water heating boilers are idle in summer, which is another distinct disadvantage.

In a recent handbook on heating an arrangement has been diagrammed in which power boilers are connected so as to be used as steam or water boilers. This in the writer's opinion is dangerous, as only one, or perhaps several, valves separate the circulating water in the heating system from the high-pressure steam in the boilers when so operated. It can be imagined what would happen if the fireman should open the valve by mistake.

With a high-pressure steam boiler a reduction in load causes the pressure to rise, closing the damper, and the steam and water in the boiler form a storage for the surplus heat of the fire. The latent heat in steam gives a rapid relief when the boiler blows off and the boiler more rapidly adjusts itself to sudden changes in load.

The temperature in the hot-water boiler would have to be reduced gradually and, although the water in the boiler has considerable storage capacity for heat absorption, it is all sensible heat and the surplus has to pass into the heating system when not needed, or with no steam space the pressure will go up rapidly. It is a common occurrence to have a change of from 25 to 50 deg. in outside temperature during a week and this change sometimes occurs in a few hours. When the outside temperature ranges from 10 to 20 deg. the requirements are 80 per cent. of the maximum heating load at zero. At 40 to 50 deg. outside temperature the load would be 36 per cent. of the maximum, or less than 50 per cent. of the former requirement. In hot-water boilers the fires would have to be withdrawn and rebuilt or banked for a period of hours to perhaps days, as the requirements demanded. As the peak heating load only occurs from 2 to 6 per cent. of the short period even at the cost of more fuel.

With a live-steam heater efficiently covered and a sealed steam circuit, there would be practically no loss except by radiation and such a heater for, say, 60,000 sq.ft. of heating surface can be installed and connected for less than $1000. By its use there would be fewer fires to take care of and less banking in the periods between peak loads. Of course, if the steam boilers were old and weakened, so as to be unfit for high pressure, it would not make any great difference whether they were placed in the water circuit directly or not.

Editorials

Utilizing a Great Natural Resource

Long as it has been known that there is power in falling water, it has remained for the present decade to show a serious disposition to utilize any appreciable part of this great natural resource. Scientists and students of the situation have repeatedly warned us of the ultimate exhaustion of our fuel supplies, only to be accounted as alarmists by some, while others, almost as heedless, have dismissed thought of the consequence of such a prospect, evidently misapplying the biblical admonition, "Sufficient unto the day is the evil thereof." Rather selfishly, it would seem, they would leave it to coming generations to worry about, justifying themselves with the prediction that, when the time comes, some substitute for coal will be found. While this may be true and there are already evidences that water will be one of the important factors in meeting the conditions, it does not relieve the present generation of its responsibility.

Beginning with a few, a steadily growing number have sensed the gravity of the combination of an ever-increasing population (and they becoming more and more demanding in the gratification of their desires for comfort and even luxuries, thus stimulating the affected industries) and a constantly diminishing store of the yet unused minerals and other raw materials. Thus has been born the Conservation Movement, at first regarded as little more than a fad, but today recognized as a worthy work and so rapidly extending its influence that no one can estimate its future importance. It is not confined to the conservation of fuels but includes more particularly at present the preservation of the forests and others of the supplies drawn from nature, the depletion of which is most threatening.

Consciously, or otherwise, the engineer has always been naturally a conservator, for, next to finding ways of doing new things, it has been his function to find new ways of doing old things more efficiently, which means at less expense. Although his motive has been reduction of cost per unit of production, he has, nevertheless, served significantly in minimizing the waste for which those yet unborn would the sooner have suffered.

To offset the engineer's endeavors, however, there has been the human tendency to greater prodigality in the use of everything that is made cheaper. As fast, for example, as means of transportation have been improved in economy, greater demands have been made upon them, as for greater speed, added comfort or their more extended use. So it is a question if, after all, the work of the engineer has not had the effect of accelerating the exhaustion of many of our resources.

Conservation of the supply of woods seems in a fair way to be solved. The government is active in the cause, directing attention to the need of conserving and the means of so doing. The forests are striving to replace themselves and are being assisted by cultivation and by precautions against their destruction by fire. When consumption gets ahead of growth, advancing prices discourage waste and even many uses so that metal substitutes are found, and the attractiveness of profits in the field of forestry draws more into the ranks. More or less automatically, therefore, forest preservation takes care of itself.

But what shall be done for heat, light and power when coal, gas and oil are gone? From seed to cut timber is a matter of a few years, but our mineral resources were ages in the forming. The next most evident step, then, and the time to take it is now, that the fuels may last the longer, is the utilization of water powers. Although more has been done recently than ever before, it is as nothing to what may be done before any considerable part of the immense available supply of energy from this source is in service.

What a contrast is afforded between the small beginnings in New England a century or so ago when that was the only industrial center of this country, and the plants in the Middle and Far West and the South which have lately been put into commission. Compare the old undershot and overshot wheels of that earlier time which got such a small part of the energy out of the falls, with the present highly efficient hydraulic turbines. Then, use of the power was restricted to within distances reachable by belt or rope transmission. Today, by electric current, the power is being distributed over hundreds of miles.

As boys we stood down by the old sawmill and watched the water pour over its clumsy wheel and it was all very wonderful to us. Now, older and less impressionable, we are still more thrilled when we stand in a plant such as those at Keokuk, Hale's Bar or Tallulah Falls, described on another page of this issue, and hear the hum of the mighty machinery or gaze over the construction work that brings this power to the generators. Truly we can but marvel when we think of what has been done and conjecture what may be.

The Cinder-Catching Problem

The evolution of cinder-catcher apparatus, as carried out at the Waterside stations of the New York Edison Co., will be described in POWER in a series of articles, the first of which appears in this issue. Engineers acquainted with modern boiler and metallurgical-furnace practice know that much has been accomplished in recent years in abating smoke from such furnaces, but that little has been done in contriving an apparatus to successfully catch the cinder.

There will also be described for the first time, and often in detail, numerous cinder-catching schemes, many of which, although not suitable for the Waterside stations, should prove valuable in smaller plants where the conditions are less extreme. These devices should also be helpful to engineers confronted with the cinder nuisance in central stations, in cement and even in factory

plants in thickly settled districts or near parks, where vegetation is destroyed. Smoke-inspection departments should find many valuable suggestions applicable to their work.

It is gratifying to know that with baffles and piping of suitable material, the water in the cinder-catchers may be used over and over, although much make-up water is needed to replace that lost by evaporation and in spray carried away by the gases. To avoid unduly rapid deterioration of the metals it would be better to draw off the water and suppy fresh water more often rather than continue its use until it became heavily impregnated with the sulphurous and sulphuric acids. This, of course, would depend on the cost of pumping, whether the plant was close to a river or other water source, and to the price of water if purchased from the city. Probably there are cities which would sell water at reduced rates for cinder-arrester purposes that they might rid themselves of the nuisance as it now exists.

Public-Utility Securities

One of the favorite arguments of the water-power interests against government charges for water privileges is the high initial investment necessary and the financial risk involved. That the first cost is usually high is undeniable, but in the light of recent statistics the risk appears more fanciful than real.

The particular statistics to which we refer were compiled by Henry L. Doherty & Co., a well known firm of bankers and extensive dealers in public-utility securities. The statistics cover a period of ten years and by means of charts show clearly the comparative increase in outstanding securities of gas and electric, steam railroad and industrial companies, also the net earnings in each class. In spite of an increase in railroad securities of 54 per cent. during this period, the rate of net earnings has remained fairly constant, averaging about 4.25 per cent. The increase in industrial securities was less than 20 per cent. and the net earnings averaged 7.79 per cent., although with violent fluctuations. In striking contrast has been the increase in gas and electric securities, of 110 per cent., with an average net return of 8½ per cent. Moreover, this rate has been particularly constant.

Of still greater significance in showing the stability of public-utility securities is the fact that the average annual amounts of securities in receivers' hands per $100 of outstanding securities for the past 30 years has been as follows: Gas and electric companies, 37 cents; national banks, $1.93; railroads, $1.84, and industrial establishments, $2.07. These figures include all gas and electric companies and steam railroads in the United States and all industrial concerns large enough to have been mentioned in financial reports. Just what proportion of these electrical securities represent water-power developments and what proportion steam plants, is not stated, nor is it shown how the average return on steam plants compares with that on water-power plants; such a comparison would be most instructive. Government reports, however, for this period, show that water-power development increased by nearly 200 per cent., which is even greater than the combined utilities. Hence, it may be assumed that the net earnings as stated fairly represent those on water-power developments, and that instead of representing a risk they are actually safe and attractive investments.

Safety Valves on Superheaters

A correspondent calls attention on page 132 to an interesting situation. A rule formulated by the Massachusetts Board of Boiler Rules and adopted by the Ohio Board prescribes that: "When a superheater can be shut off from a boiler, whether attached or separately fired, it shall have an ample safety valve *at or near the steam inlet.*"

If the only purpose of the valve were to relieve the superheater from an accumulation of pressure when it was shut off from the boiler, it would not seem to make much difference whether it were located at the inlet or the outlet of the superheater. The motive in setting the valve at the inlet was apparently to save it from the effects of the superheated steam; but when the superheater is shut off from the boiler, which it would be in this case, by a valve between the safety valve and the boiler, all that it could discharge would be very highly superheated steam, although there would not be much of it, and the valve might as well be located at the outlet or the middle of the superheater.

A safety valve located at the outlet of the superheater, however, and set a few pounds lower than the safety valve on the boiler itself, serves another useful purpose which justifies its use even when the superheater cannot be shut off from the boiler and is guarded against overpressure by the main safety valve. In case of a sudden and serious diminution of the call for steam the boiler will relieve itself through the superheater, keeping it from burning out while the fires are being brought under control. But a safety valve so located does not comply with the law. There is nothing to prevent the use of two, one to save the superheater and the other to satisfy the inspector, but it would be interesting to know why that upon the outlet would not serve every purpose of safety in the case of a superheater which "can be shut off from a boiler" besides furnishing a precaution against the injury of the superheater when it is not so shut off.

The Babcock & Wilcox boilers at one of the stations of the Boston Elevated Railway Co. are set eight feet above the stoker grate, at the rear or lowest end. It is interesting to know that should more boilers be installed this distance may be increased, but surely never diminished. From all indications, we may expect to see an extensive application of the scheme of raising boilers much higher above the grate than has heretofore been practiced.

The announcement that the engineering departments of Harvard University and the Massachusetts Institute of Technology are to merge, may be regarded as one of the most important educational steps of recent years. The already splendid organization of the Institute, with its recent acquisition of funds for new buildings and equipment, augmented by the liberal endowment of Harvard, should make it possible to set a new standard for engineering instruction and at the same time take up research work on an extensive scale, as is being done by some of the European universities.

We are glad to see that the daily press has at last taken up the question of electricity rates in New York City. This should be a potent factor in arousing the interest of those most concerned.

Correspondence

Excess Air and CO_2

H. L. H. Smith's article on the above subject, in the Nov. 25 issue, was read with a mingled feeling of sympathy and amusement. Someone has evidently been bombarding Mr. Smith with "excess air," so long ("six or eight years") and so persistently that it got on his nerves. This excess of "excess air" and CO_2 argument with which Mr. Smith has been so "continually afflicted and pastered with" must have been local and possibly personal. The technical press certainly has not given this question undue consideration, since the majority of operating engineers still seem to lack a clear understanding of what is necessary to *attain* and *maintain* maximum boiler efficiency.

Mr. Smith asks: "Why do we speak of excess air at all, why not substitute deficiency of coal?" There are several reasons why it is more logical to speak of excess of air than of deficiency of coal.

1. Because the first is definite and the second is indefinite. For any given fuel, a definite per cent. of CO_2 means a definite per cent. of excess air. If the fuel were pure carbon, the excess of air would be as follows: For 7 per cent. CO_2 200 per cent., 10½ per cent. CO_2 100 per cent., 14 per cent. CO_2 50 per cent. excess. This relation is also very nearly correct for anthracite coal, but the excess of air for a given per cent. of CO_2 becomes less as the content of hydrogen in the fuel increases, but the relation is always a definite one. Furthermore, every per cent. of excess of air carries to waste up the chimney a definite amount of heat for every pound of coal consumed. On the other hand, what relation is there between CO_2 and deficiency of coal on the grate? For example, what per cent., how many pounds or shovels full of coal deficiency does 7 per cent. of CO_2 represent? The idea is absurd and really does not matter, but what does matter is Mr. Smith's remedy. He says: "If the CO_2 is thought undesirably low, and the draft is fixed, let the fireman shovel coal more rapidly." This will, no doubt, increase the rate of driving and may result in a higher per cent. of CO_2 but it by no means follows that it will be conducive to fuel economy, because:

2. The low CO_2 (excess air) may be due to other causes than a thin fire (deficiency of coal). There may be ample coal on the grate, but if it is not evenly spread, low CO_2 will result; in which case shoveling coal more rapidly will only aggravate the waste because of a deficiency of air through part of the fuel bed, resulting in incomplete combustion. What is needed is not more rapid shoveling of coal but more careful and skillful firing.

3. All the excess of air does not come through grates. From 50 to 100 per cent. or more may come in through cracks in the setting, loose door frames and warped cleaning door, and by infiltration through the pores of the brick.

Air entering beyond the fire does not aid combustion and is just as damaging to economy as though it came through the fire. Under these conditions, which are most likely to be found where the accelerated coal-shoveling idea prevails, if the per cent. of CO_2 is forced up by thickening the fire, the beneficial effect obtained from the increased CO_2 may be fully neutralized by incomplete combustion, due to deficiency of air through the fire.

Mr. Smith's statement that "in general the rate of steaming follows the rate of shoveling" is true, but there is a vast difference between shoveling coal and economical firing, and the proposition to bring up the per cent. of CO_2 by merely increasing the speed of the shovel is entirely wrong.

The first step to increase the per cent. of CO_2 is to stop all the air leaks beyond the furnace. The second is to maintain an even fire of the proper thickness, by regular, skillful and careful firing. The third is to regulate the air supply so as to produce the highest per cent. of CO_2 compatible with complete combustion. The speed of the shovel must always keep pace with the demand for steam. If these conditions are fulfilled, it will not have to be accelerated merely to increase the per cent. of CO_2, and high CO_2 will spell high efficiency.

E. A. Uehling.

Passaic, N. J.

Accident as Evidence of Negligence

There is a rule of law applicable to personal injury cases that when an instrumentality which caused the accident without fault of the injured person is shown to have been under the exclusive control of the defendant, and that the injury is such as in the ordinary course of things does not occur if the one having such control uses proper care, it affords reasonable evidence, in the absence of an explanation, that the injury arose from the defendant's actionable negligence.

In the case of Hill vs. the Pacific Gas & Electric Co., 136 "Pacific Reporter" 492, which was recently before the California District Court of Appeal, it appeared that the defendant power company supplied electricity to a mining company through a wire carrying 4400 volts, and that an employee of the latter company was electrocuted while attempting to switch power to a pump. The plaintiff, in suing to recover damage on account of the accident, attempted to invoke the rule above stated, but the court decided that it was not applicable to the power company—that an electric power company is under no obligations to examine and inspect the fixtures and appliances used by its customers and under their control. The court found that the power company's control ended at the meter, and said in part: "Plaintiff's contention is that, because of the extremely dangerous character of this element brought into use by these electric power companies, they should be compelled not only to superintend the installation of all appliances constructed to receive and utilize this dangerous element,

but should be charged with such inspections from time to time of all such appliances as would relieve the power companies from the charge of want of care and would enable them at all times to explain that any accident which might happen through its use was not the result of want of care on their part. When we consider the multitudinous uses to which electricity is now being applied, and assuming that the user receives it by means of appliances of his own choice, erected by himself, and under his control and management, as in the present case, it would be an intolerable burden to require of the power companies what is here contended for."

It was further held by the court that it was open to the jury to find, under the rule referred to, that the mining company was guilty of negligence. Therefore the plaintiff not only joined the power company and the mining company as defendants, but also included the president of the company and the electrician who installed the appliances. The court, finding that the president employed a competent electrician and that the mode of installation was not negligent, exonerated both of them. Hence, judgment against the plaintiff, awarded by the trial court, was affirmed as to the power company and the individual defendants and was reversed as to the mining company, a new trial being awarded against that company.

A. L. H. Street.

St. Paul, Minn.

Old Motor Drives Improvised Emery Wheel

It was found necessary to use an emery wheel quite often during the day, and the company did not choose to get one for the power house. The machine shop was quite a distance from the power house and much time was spent in going to and from the shop whenever it was necessary to use the emery wheel. I then began to look around for something to make one of.

In the electrical department I found four 15-hp. Edison bi-polar shunt-wound motors of an old type that had been replaced with better machines. The armatures of these machines were of the hand-wound type, and the shafts and commutators were so badly worn that they were not worth repairing for use in the mill. Among the lot we found two field coils that were sound, and one armature that had only four coils cut out, and decided that this could be made to drive an emery wheel. The shaft extended past both bearings. One end of the shaft was turned down from 1¼ to 1 in., and threaded with a right-hand thread. Also two collars were turned out, one to fit against the shoulder and the other against the emery wheel.

The other end of the shaft was arranged to carry a grinding disk for polishing the nuts and caps of the water-tube boilers. The end of the shaft was turned down to ¾ in., and threaded with a left-hand thread. The grinding disks were made ½ in. thick by 8 in. in diameter and tapped to fit the stud on the end of the shaft, and were finished with a rough cut. Round pieces of emery paper of the proper grade were glued on each side of these disks, the rough surface helping to hold the paper. We had several of these disks made and covered. The old paper when worn out was removed by placing the plate in hot water.

The machine was bolted against the wall in the boiler room, and a rest made to steady the work when using the emery wheel. The original speed of the motor was 1300 r.p.m., but with four coils cut out it ran somewhat faster than this.

J. C. Hawkins.

Hyattsville, Md.

Kerosene Carburetor

In the Jan. 6 issue an article by J. A. Lucas appears entitled, "A Unique Kerosene Carbureter," describing a process produced by Alexander E. Porter, 171 Broadway, New York.

From reading the article it would appear that Mr. Porter had invented and developed this process, yet if Mr. Lucas had thoroughly investigated this matter he would have found that the patent covering this process was in the names of Alexander T. Porter and Herbert E. Rider, dated June 10, 1913, and that by some mistake in the United States Patent Office this patent was issued when an application for letters patent by Granville S. Rider covering the same process was pending, having been filed some three months previous to the Porter-Rider application for a patent.

However, this patent has been put in interference with the G. S. Rider application and is now before the United States Patent Office for adjudication.

E. M. Engelman, President,
Rider Gasifier Co.

New York City.

Location of Safety Valves on Superheaters

An engineer friend has put a question of law to me that I am unable to answer; possibly some of the readers of Power may be interested and able to offer some helpful suggestions. My friend has two boilers that are equipped with superheaters. The superheaters were provided with safety valves as advised by the superheater manufacturers, and these valves were located directly on the outlet pipes from the superheaters. A boiler inspector came along some time ago and told my friend that he did not have his boilers equipped according to law, and referred him to a rule given on page 60* of the Ohio Boiler Rules, which reads as follows:

> When a superheater can be shut off from a boiler, whether attached or separately fired, it shall have an ample safety valve at or near the steam inlet.

My friend and the inspector had a long argument about why the steam could not be released equally well from either end or the middle of a superheater, with the inspector on the losing side, when suddenly the inspector brightened up and said that they were both chumps, for, of course, the safety valve was required to be placed on the inlet pipe to protect the valve from the superheated steam. This argument completely captivated my friend, the engineer, and he thanked the inspector and proceeded to relocate the valves as required.

Recently, my friend took a trip to Chicago, and naturally visited some of the big power plants. At one plant he found superheaters attached to the boilers without any

*Page 90, Ohio Rules, Edition of September, 1913; page 48, Massachusetts Rules, Edition of September, 1911.

stop valves between them and the superheaters but all provided with safety valves on the outlets from the superheaters. He felt a little leery about pointing out defects to the engineer who was showing him around but finally overcame his timidity and told the engineer that he wished to show him an error in the equipment that was provided against by the Ohio Rules, and proceeded to enlighten him on the proper location of safety valves for superheaters. The Chicago engineer listened attentively until my friend had finished and then had a long hearty laugh. He told my friend that it had cost his company several thousand dollars to learn that superheaters should always have safety valves placed on the outlet pipe, and that such valves must be always set a few pounds below the popping point of the valves on the boilers, so that the superheater valves would be certain to act first. The engineer explained that unless this was the case a sudden throwing off of the load on the plant would stop the flow of steam through the superheater, and without this flow the superheaters were liable to be overheated and ruined, before the fires could be checked. He said that several accidents of this kind, where the valves on the superheaters were set at too high a pressure, had caused a big expense to his company, on account of "fried superheaters" as he expressed it. The Chicago engineer said that if the Ohio Boiler Rules were made to protect the safety valve, they should have specified the outside-spring type of valve for such use, and he also stated that these valves should have been specified properly located and set, to prevent injury to the superheater, which he claimed was the real purpose of safety valves for superheaters.

My friend is now thoroughly convinced that the Chicago engineer knows more about the matter than the makers of the rules, and is between the devil and the deep blue sea; he cannot change his valves without violating the law and he lives in mortal dread of a sudden break down in the plant presenting him with a couple of "fried superheaters." What he would like to know is, can his company collect damages from the state of Ohio in case his superheaters are ruined by complying with the law. I have passed the question up. I understand that this rule was copied from the Massachusetts rules and that such a rule is still in force in that state; if so, the question of my friend may be of interest to engineers in the state of Massachusetts.

J. K. Linderhurst.

Toledo, Ohio.

Locating Grounds on Transformer Secondaries

Until recently, a certain central station had considerable trouble in locating grounds on the secondaries of lighting transformers supplying a number of consumers. Most of the grounds, while in themselves not serious, caused a drop in voltage, resulting in complaints about poor lights. An inspection of the wiring on the premises of each consumer was then necessary in order to locate the fault which was generally found in the lamp fixture.

As this inspection consumed much time, a scheme was devised which made use of a 220-volt recording voltmeter connected between the ground and the ungrounded leg of the three-wire service. All that then remained for the inspector to do was to visit each house which received service from the grounded transformer, pull out the main switch for an instant and note the exact time at which the observation was made.

By consulting the chart obtained from the recording voltmeter and comparing the time at which a drop in voltage occurred with the record of time taken while on the premises of different consumers, the house containing the faulty wiring could be located, for upon opening the switch feeding the ground a drop in voltage would have occurred. This scheme worked successfully on circuits having one or more grounds, since upon the removal of any one, a drop in voltage resulted. Upon removal of all the grounds normal voltage (110 volts) would be recorded. The voltmeter can be connected at any point on the transformer secondary.

F. H. Oberschmidt.

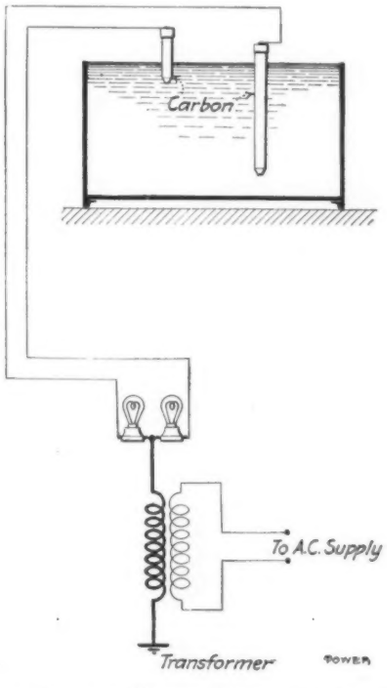
Cincinnati, Ohio.

Another Electric Water-Level Indicator

Water for our barometric condenser is supplied from a cooling tower above the condenser and above the engine-room roof; consequently some means for determining the water level in the pan under the tower was desirable. The pan is shallow, it being only 5 in. from the bottom of the pan to the overflow.

A float was found to be impracticable so the following arrangement was made.

A 200-watt transformer was connected as shown in



Continuous Water-Level Indicator

the sketch. One side of the transformer was grounded and the other side was connected through a pair of lamps in multiple to the water level in the pan. The terminals were a pair of arc-lamp carbons. One was adjusted to make contact with the water just before the pan went dry. A red light indicated overflow, a white light safe water level and no light, no water, and that it was time for the attendants to get busy.

Thomas G. Thurston.

Chicago, Ill.

Safety-Valve Action Discussed

Relative to the safety-valve problem for discussion in the issue of Nov. 18, page 729, I beg to offer the following: The writer of the letter, Mr. Hastings, failed to state what size valve it was that raised $\frac{3}{16}$ in. from the seat and then quickly opened wide. It is rarely that the mechanism of any valve will allow of a lift of more than $\frac{1}{8}$ in. per inch of seat opening, i.e., a 1-in. valve could not lift more than $\frac{1}{8}$ in. probably, or a 2-in. more than $\frac{1}{4}$ in. without the lever or some other part of the mechanism striking a stop. This stop is provided not so much as a precaution against the valves blowing wide open in ordinary operation, as this is very unlikely as further explanation will show, but in case the weight should be misplaced on the lever or moved by accident from its proper location it prevents the lever from lifting so high as to cause the weight to slide back on the same and so, of course, prevent the valve from closing until the pressure is greatly reduced.

The conditions stated by Mr. Hastings in the last sentence of the first paragraph of his letter are contrary to my experience with this type of valve and are also contrary to reasonable deduction from the conditions of operation. Mr. Hastings neglects to state whether, after the pressure had been allowed to accumulate to 2 or 3 lb. above the setting, and the lever then released, he maintained the pressure under the disk at this point or allowed the valve to reduce the pressure.

In experiments with which the writer is familiar even if the pressure under the disk were maintained considerably above the setting by supplying a larger quantity of steam than the valve was suited to discharge the disk still lifted not more than $\frac{1}{32}$ to $\frac{1}{16}$ in. for, say, a 1½-in. valve and only slightly more for a larger-sized valve. The reason appears very apparent, for, as the writer states, the velocity head of the issuing steam would be twice far enough above the seat to enable this head to act on it. In fact, the direction of flow of the issuing stream is not upward but is chiefly across the under-surface of the disk from the center outward toward the circumference and only at a slight upward angle and so there is only a small component of this velocity head which may be considered as adding to the pressure head to help it lift the disk.

Obviously the greater the lift the greater this component, but I should judge that the disk would have to lift at least as far away from the seat as the diameter of the opening to get the full effect while if it lifts one quarter of this amount the full area of the seat is provided for discharge of the steam. A further fact which prevents even this small component from adding directly to the pressure head is that the pressure is constantly decreasing under normal conditions, due to the discharge, so that the pressure head will be less after the valve opens than that which the weight is set to balance. In operation, in an extreme condition, there is no reason why the disk should open more than an amount equal to one-quarter of the diameter of the seat. This gives full area on the basis of a flat seat, and as soon as the valve opens the pressure immediately reduces under the disk to an amount less than that at which the steam started to discharge, because the connecting pipe, even though short, cannot maintain the pressure and the disk is held up by the pressure plus the component of the velocity head until this sum reduces to less than the setting when the disk closes. It would be foolish to state that it would be impossible to blow a valve of this type wide open if the mechanism would allow it. The only conditions under which it would be done would be in case the pressure continued to increase after the valve opened or in case the valve stuck, so as to let a considerable overpressure accumulate before it opened, and no reputable manufacturer would furnish a valve with a mechanism that would allow this to happen.

Cincinnati, Ohio. E. G. GREENMAN.

Pipe Work and Fittings

In the issue of Dec. 9, a correspondent comments on the carelessness of engineers in running pipe lines and on the use of unnecessary fittings. He also laments the general ignorance of so called engineers and their lack of ability. If Jones at the sawmill packs his piston rods with a cotton clothesline, soaked in tallow, that is his affair. His boiler only carries 60 lb. steam pressure, and if the packing does leak, he has plenty of water and sawdust fuel, and blowing steam may be music to his ears.

Getting back to engineers in general, how many know that pipe lengths over 12 in. in diameter are measured on the outside? That but five standard thread sizes are used for all sizes of pipe from the smallest to the 12-in.? That large pipe lengths are not made for threading when ¼ in. thick or less, as the threads would cut too deep.

Valves have leaked when connected up because strains in the pipe line have warped the valve seat, or because a wrench was used on the wrong end of the valve when it was screwed in place. Always use the wrench on the end of the valve being screwed on the pipe. When running large pipe, each length should be supported independently of the rest of the line and rest on roller brackets.

The weight of a pipe line should never be carried by a valve in the line, as a large valve seat may be warped by the strain; always have the pipes in line before bolting together. Neglect of this will cause leaky joints when the strain of holding the pipe in line comes on the bolts, gaskets and flanges.

When several engines take steam from a common steam line, a certain load on the engines will often cause vibration. This can be overcome by suitably bracing the pipe line, taking care that the braces do not interfere with the piping, thus causing serious strains on some part of the system. It is better to brace a pipe near the boiler.

Mr. Purcell, in the Dec. 16 issue, makes a suggestion for priming a condenser circulating pump, but does not state if a surface or jet condenser is meant. He evidently refers to a surface condenser, as the circulating pump of a jet condenser is acted on by the vacuum and his device would not be necessary.

His scheme will work, but if his proposed pipe from the circulating-pump casing to the dry-vacuum pump were tapped in the circulating-water line, between the circulating pump and condenser, and the other end tapped into the condenser proper, the water would come high enough in the suction line for the pump to pick it up and force it through the condenser. There would then be no danger of getting water in the dry-vacuum pump, as any water brought over through the priming pipe would go to the condenser and be carried off with the water of condensation.

Philipsburg, Penn. J. H. HOFFMAN.

Inquiries of General Interest

Density of Steam—What is meant by the density of steam?

H. T.

Density of a substance is the relation of its weight to its bulk or volume, and in steam engineering the density of steam is usually quoted as weight in pounds per cubic foot.

Distinguishing the Positive from the Negative Electrode—By immersing a positive and a negative electrode in a sal-ammoniac solution, which will give off the greater number of bubbles?

G. K.

The negative electrode.

Removing Burnt Cylinder Oil from Bright Surfaces—How can a deposit and discoloration due to burnt cylinder oil be removed from finished metallic surfaces?

J. T. H.

Any gummy hydrocarbon can be removed with gasoline; if a noninflammable application is to be preferred, use carbon tetrachloride. The solid carbonaceous matter has to be removed by scraping, or by burning with a jet of oxygen gas. Discoloration would have to be removed by refinishing.

Pressure and Velocity—Why does it require four times the pressure to double the velocity of flow of steam?

J. W. D.

The velocity of flow of a fluid is as the square root of the pressure. It is a fundamental law of nature. Water, for instance, issues with the same velocity from the center of an aperture in the side of a reservoir as the velocity which would be attained by a body falling through a height equal to the distance from the surface of the water to the center of the aperture and it is known by observation that such velocity is as the square root of the height, hence it requires four times the height or pressure to double the velocity.

Relative Sizes of Pump-Suction and Discharge Lines—Why is a pump-suction line generally made larger than the discharge line?

E. M.

For a given discharge per minute loss of pressure in a pipe line decreases with increase in the size of the pipe. The loss of head due to friction in a discharge line may be overcome by applying sufficient power to the pump, but with a given supply, the loss of head in a suction pipe can usually be overcome only by increasing the size of the pipe. Under most conditions, it is practicable to provide a suction line of larger size of pipe than that of the discharge line.

Hammering in Suction Pipe—How can the hammering noise in a pump suction pipe be prevented where the water is supplied under pressure?

M. B.

The hammering is due to sudden checking of the velocity of the water in the pipe and can be reduced by increasing the size of the supply pipe, or by providing an air chamber on the suction pipe near the pump. Such an air chamber for a single-cylinder pump should have a volume of about six times the displacement of one stroke of the pump and for duplex pumps about four times the displacement of one stroke of one water cylinder. The air chamber may be of usual form, or made of a large size of iron pipe.

Horsepower of Alternators—What is the formula for finding the horsepower of two alternators in parallel from the voltmeter and ammeter when there is no wattmeter?

T. P. M.

It is not stated whether the switchboard is equipped with a power-factor meter; but assuming that it is not, and that there is a motor load, let the power factor be 80 per cent.

$$\text{Then Horsepower} = \frac{\text{Amp. per phase} \times \text{voltage (across any two leads)} \times 1.73 \times 0.85}{746}$$

This assumes that the load is balanced and the ammeter reading is taken on the line side of the busbars; if the ammeters are on the individual machines the readings will have to be added.

Absolute Pressures—What is meant by absolute back pressure and absolute terminal pressure, and what is the difference between both?

E. P.

"Absolute pressure" of any kind means pressure above vacuo and is called "absolute" because in common language pressure generally means gage pressure or boiler pressure, which is pressure above atmospheric pressure. Absolute back pressure, therefore, means the total pressure worked against by the piston including atmospheric pressure and is the back pressure ordinarily referred to, plus atmospheric pressure. Absolute terminal pressure means the pressure in a steam cylinder above vacuum, when the piston is at the end of the stroke and usually refers to the final pressure of expansion after cutoff has taken place and at the instant of release.

Computing Power of Compound Engine—Employing a single horsepower constant, what is the method of computing the horsepower of a 12x24x30-in. compound engine running 106 r.p.m., the mean effective pressure of the high-pressure cylinder being 60 lb. and that of the low pressure being 14 lb. per sq.in.?

J. H. C.

The mean effective pressure of both cylinders may be referred to either cylinder and the computation may be based on the horsepower constant of the cylinder referred to, but it is customary to refer to the low-pressure cylinder. The diameters of the cylinders being respectively 12 and 24 in., and the stroke of both pistons being 30 in., the ratio of the piston areas and of the cylinders is as 1 to 4.

Each pound mean effective pressure of the high-pressure cylinder will therefore be equivalent to ¼ lb. mean effective pressure of the low-pressure cylinder.

The low-pressure cylinder being of 24-in. diameter, the area of the low-pressure piston is 452.39 sq.in. and the horsepower constant for the low-pressure cylinder is

$$\frac{30 \times 452.39 \times 106 \times 2}{12 \times 33{,}000} = 7.265 \text{ hp.}$$

Referring the mean effective pressure of both cylinders to the low-pressure cylinder, their combined mean effective pressure referred to that cylinder would be equivalent to

$$\frac{60}{4} + 14 = 29 \text{ lb. mean effective pressure}$$

and the horsepower would be

$$7.265 \times 29 = 210.68 \text{ hp.}$$

Position for Ball on Safety-Valve Lever—At what horizontal distance from the fulcrum should the 130-lb. ball of a 3-in. lever safety valve be placed so that the valve will blow off for a boiler pressure of 90 lb., the weight of the valve being 12 lb., its distance from the fulcrum of the lever to the center of the valve being 8 in., and the lever weighing 40 lb. when supported at 20 in. from the fulcrum?

B. C. H.

The valve being 3 in. in diameter its area would be

$$3 \times 3 \times 0.7854 = 7.0686 \text{ sq.in.}$$

and the total pressure of steam tending to raise the valve would be $7.0686 \times 90 = 636.174$ lb.

The pressure on the valve due to the weight of the lever would be $\frac{20}{8} \times 40 = 100$ lb.,

and the weight of the valve being 12 lb., the downward pressure exerted by the lever and the valve would be

$$100 + 12 \text{ or } 112 \text{ lb.}$$

Therefore, neglecting friction, the net upward pressure to be resisted by the leverage of the ball would be

$$636.174 - 112 = 524.174 \text{ lb.}$$

The distance of the valve from the fulcrum being 8 in., the upward movement or leverage of steam pressure acting on the valve, which must be equaled to be balanced by the downward leverage of the ball, would be

$$8 \text{ in.} \times 524.174 \text{ lb.} = 4193.392 \text{ in.-lb.,}$$

hence a ball weighing 130 lb. would have to be so placed that its center of gravity would be

$$\frac{4193.392 \text{ in.-lb.}}{130 \text{ lb.}} = 32.254 \text{ in.}$$

or practically at 32¼ in. from the fulcrum, for the valve to blow off when the boiler pressure becomes 90 lb.

Engineers' Study Course

Trigonometry--X

Last Lesson's Answers

41. Two sides ($a = 847$, $b = 579.4$) and the included angle ($C = 36$ deg.) are given (a Case III problem). Using the first method at the end of the last lesson:

$$\tan \tfrac{1}{2}(A - B) = \frac{847 - 579.4}{847 + 579.4} \times \tan \tfrac{1}{2}(180 - 36)\ deg.$$

$$= \frac{267.6}{1426.4} \times \tan 72\ deg. = \frac{267.6 \times 3.0777}{1426.4} = 0.5774$$

Therefore $\frac{1}{2}(A - B) = 30$ deg.

Since

$$A = \tfrac{1}{2}(A + B) + \tfrac{1}{2}(A - B)$$
$$A = 72 + 30 = 102\ deg.$$

and since

$$B = \tfrac{1}{2}(A + B) - \tfrac{1}{2}(A - B)$$
$$B = 72 - 30 = 42\ deg.$$

Check: $(A + B + C = 180$ deg.)
$102 + 42 + 36 = 180\ deg.$

Side c is found from the equation $\frac{a}{c} = \frac{\sin A}{\sin C}$

$$\frac{847}{c} = \frac{0.9781}{0.5878} \qquad c = \frac{847 \times 0.5878}{0.9781} = 504.37$$

42. Given $b = 527.8$, $c = 723.6$ and $A = 100$ deg.

This, also a Case III problem, will be solved by the second method given in the last lesson, finding first the missing side from equation 28:

$$a = \sqrt{\left((527.8)^2 + (723.6)^2 - [2 \times 527.8 \times 723.6 \times (-0.1736)]\right)}$$

$$a\ \sqrt{278{,}572.84 + 523{,}596.96 + 132{,}601.26}$$

$$= \sqrt{934{,}771.84} = 966.8$$

(Note that C being an angle of the second quadrant, its cosine is negative. See Table II, Lesson II).

From equation 27,

$$\frac{966.8}{527.8} = \frac{0.9848}{\sin B} \qquad \sin B = \frac{527.8 \times 0.9848}{966.8} = 0.6352$$

Therefore angle $B = 32\frac{1}{2}$ deg., closely.

From equation $\frac{a}{c} = \frac{\sin A}{\sin C}$

$$\frac{966.8}{723.6} = \frac{0.9848}{\sin C} \qquad \sin C = \frac{723.6 \times 0.9848}{966.8} = 0.7388$$

Therefore angle $C = 47\frac{1}{2}$ deg., closely.

43. Given $a = 60$ ft., $b = 60$ ft., and $C = 110$ deg.; required the side c.

This can be found directly from the equation

$$c = \sqrt{a^2 + b^2 - 2ab\cos C}$$

$$c = \sqrt{(60 \times 60) + (60 \times 60) - [2 \times 60 \times 60 \times (-0.342)]}$$

$$= \sqrt{9662.4} = 98.297\ ft.\ or\ about\ 98\ ft.\ 3\tfrac{1}{2}\ in.$$

44. Again, two sides (50 and 90 yd.) and the included angle (37 deg.) are given; required the third side.

From the same equation as in the last problem

$$c = \sqrt{(50 + 50) + (90 \times 90) - (2 \times 50 \times 90 \times 0.7986)}$$

$$c = \sqrt{3457.6} = 58.8014\ yd.\ or\ about\ 58\ yd.\ 2\ ft.\ 5\ in.$$

45. This problem requires the solution of two triangles, first the triangle $ABCA$, Fig. 10, and then $BCDB$. The sides $AB = 15$ ft. and $AC = 45$ ft. and the included angle $CAB = 84$ deg. are given. Then, by the first method of solving:

$$\tan \tfrac{1}{2}(\angle ABC - \angle ACB) = \frac{45 - 15}{45 + 15} \times \tan \tfrac{1}{2}$$

$$(180 - 84)\ deg. = \tfrac{30}{60} \times \tan 48\ deg. = \frac{30 \times 1.1106}{60} = 0.5553$$

Therefore $\frac{1}{2} \angle ABC - \angle ACB = 29$ deg., very nearly.

Since $\frac{1}{2}(\angle ABC + \angle ACB) = 48$ deg.

$$\angle ABC = 48 + 29 = 77\ deg.$$

and

$$\angle ACB = 48 - 29 = 19\ deg.$$

Finding the third side, CB, by the Law of Sines:

$$\frac{CB}{45} = \frac{\sin 84\ deg.}{\sin 77\ deg.} = \frac{0.9945}{0.9744} \qquad CB = \frac{45 \times 0.9945}{0.9744} = 45.928$$

Since

$$\angle CBD = \angle ABD - \angle ABC$$

and

$$\angle ABD = \angle CAB = 84\ deg.$$
$$\angle CBD = 84 - 77 = 7\ deg.$$

Of the triangle $BCDB$ there are now known the side BC (45.923 ft.), the side DB (45 ft., being equal to AC) and the included angle CBD (7 deg.).

Solving by the second method to find the side CD directly,

$$CD = \sqrt{(45.923)^2 + (45)^2 - (2 \times 45.923 \times 45 \times 0.9925)}$$

$$CD = \sqrt{31.8} = 5.639\ or\ about\ 5\ ft.\ 7\tfrac{1}{2}\ in.$$

A short cut to the solution of the second triangle would have been to use the Law of Sines. The angle ABC was found to be 77 deg. and, CD and AB being parallel, the angle BCD equals ABC, hence is also 77 deg. This and the angle CBD and the side BD being known, it becomes a Case I problem, and

$$\frac{CD}{45} = \frac{\sin CBD}{\sin BCD} = \frac{\sin 7\ deg.}{\sin 77\ deg.} = \frac{0.1219}{0.9744}$$

$$CD = \frac{45 \times 0.1219}{0.9744} = 5.63$$

which is a check upon the answer already found.

When it is desired to be sure of the result of any solution of a Case III problem it is well to employ both the Law of Tangents and the Law of Cosines methods and see that the same answer is obtained with both.

Solution of Oblique Triangles Continued

Case IV

When the three sides of a triangle are given, the angles may be found directly from the equations expressing the

Law of Cosines. For example,

$$a^2 = b^2 + c^2 - 2\,bc\,\cos A$$

by transposition becomes,

$$\cos A = \frac{b^2 + c^2 - a^2}{2\,bc}$$

Similarly,

$$\cos B = \frac{a^2 + c^2 - b^2}{2\,ac} \qquad (31)$$

$$\cos C = \frac{a^2 + b^2 - c^2}{2\,ab}$$

When two angles have been found the third may be obtained by subtracting the sum of the other two from 180 deg., but usually it is safer to solve all three angles in the regular way and then see that the three total 180 deg. as a check on all of the calculations.

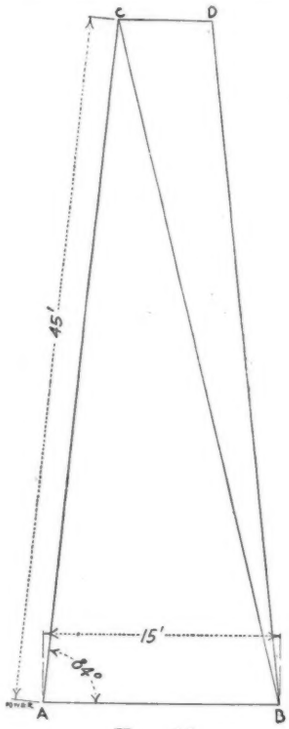


FIG. 10

There is likely to be some discrepancy when the three angles are totaled, especially if any of them involve fractions of degrees. This is because the differences between functions degree by degree are not equal and it is more or less of an approximation when degrees are split, to divide the functions proportionately, as with the use of a table, such as that in Lesson II. More complete tables reduce this error, but there is still apt to be a slight one when the three angles of a triangle are totaled, due to the calculations not being carried out to a sufficient number of decimal places. Unless, therefore, a material error is found in the 180-deg. total, it does not indicate any serious mistake in the calculations. Such difference as is found should be added or subtracted as the case may be, among the angles most likely to be in error. Generally in solutions by the Law of Cosines the bulk, if not all of the correction should be made to the smallest angle, for the cosines of angles near 0 deg. differ only slightly from one another, as may be seen from the table.

Areas of Triangles

The commonly known rule that the area of a triangle is equal to half the product of the base by the altitude generally is sufficient, but for the case of an oblique triangle of which the altitude is not known, although three or more of its parts may be, it becomes more convenient to use another rule which is:

The area of a triangle is equal to half the product of two sides and the sine of the included angle.

This may be proved as follows:

Referring to triangle *ABCA*, Figs. 11 or 12, by the familiar rule,

$$area = \tfrac{1}{2}\,c \times CD$$

But since $CD = a \sin B$ (Lesson VII).

$$area = \tfrac{1}{2}\,ac \sin B \qquad (32)$$

The area of a triangle can then be solved if three parts are given, for if these do not happen to be two sides and the included angle, the latter can be calculated from the known parts, as explained in this and the two previous lessons.

Study Questions

46. Given $a = 9$, $b = 12$ and $c = 15$; find the angles.

47. Given $a = 94.596$, $b = 104.653$ and $c = 100$; find A, B and C.

48. The only available site for a cooling pond is triangular in shape. The three sides measure respectively 100, 150 and 75 ft. What will be the angles at the corners of the pond?

49. Taking the above as the inside dimensions of the pond and that its depth is uniformly 5 ft., how much water will it contain?

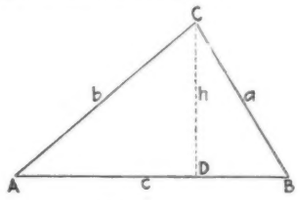


FIG. 11

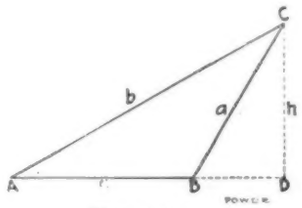


FIG. 12

50. A triangular guard is placed at one side of a rope drive which comes up through the floor. Its base is 6 ft., its altitude 8 ft. and one of the two inclined sides, which are parallel with the corresponding runs of the rope, is 8 ft. 6 in. What is the angle between the two runs of the rope?

Water-Power Control in West Virginia

Hydro-electric companies are at the present time deeply interested in the outcome of the conferences being held by the Public Service Commission to determine the plan under which the water development of West Virginia is to be carried on. Application for permission to erect dams are on file covering the Kanawha, New Gauley, Williams, Meadow, Elk, Buchannon, Cheat and West Fork Rivers. In some instances work has been started and near the Pennsylvania state line a mammoth dam on Cheat River has been partially completed.

The commission has prepared an outline of the form of permit it will present for discussion and unless material changes are made in it the regulation the commission would exercise over the hydro-electric companies would be the most complete ever attempted over any public-service corporation in West Virginia.

Every act of the hydro-electric companies from the purchase of the land, which would be submerged, would be subject to supervision, the commission would determine the capacity of the water plants and finally limit the net earnings of the companies, taking for the state 75 per cent. of the net earnings of the companies over 12 per cent. and placing it in a fund to be used ultimately for the purchase of the plants for the state.

Oil Refining Processes Improving—There has been unusual progress in many parts of the country during the past year in petroleum refining, especially in the dehydration of heavy crude oils, in obtaining gasoline from natural gas and synthetically from heavy oils.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"Ford is 500 years ahead of his time," says Edison, referring to Mr. Ford's intention of distributing ten million dollars annually among his employees. Does Edison mean that it will be 500 years before any other concern does this little thing for us?

A big electrical manufacturing company sends us a story of "Faithful Service—Machinist Works 22 Years on One Machine." And remarks: "It is peculiarly refreshing to see one who has pursued the even tenor of his way undisturbed by the clamor about him." The life of the machine reflects credit on its maker, but we'd not say the same for this even-tenor feller. My gollies! think of putting in 22 years on a 2-in. turret lathe. No wonder he has an even tenor. Some ambition!

"Women shared in every important conference or movement in Great Britain the past year"—New York "World." Why, ever since that Eden episode they have been our wives, mothers and sisters (and other fellows' sisters). On this bright and sunny day we are even trying to think kindly of that lady typist who says her dictionary is always wrong—and spells accordingly.

By the way some folks nurse a grouch, you'd think that radium was its only cure, and that they were too poor to buy even a couple of pounds of remedy.

To those that go down to the sea in ships there has been added a new terror of the sea, the tango. Hitherto, our many trips to Europe have been for rest and recuperation. If we have to tango our way over in future, we'll quit—and go to Milwaukee in September.

Just one good word for an explosion. It occurred 439 ft. under a New York street and opened up the Catskill Aqueduct. The other side of the shield is that this tunnel has cost the lives of 283 men and injured 8833!

"Get out of one ton of coal the value of two!" Same old goldbrick, same old shell game. This time it's the "Fuel Economizer Mfg. Co." The "Economizer" prolongs the life of the fire at a "travial" cost and the powder is "dessolved" in water. Aha! Mister Sukker takes a 50-cent box. Who's next? E. Z. Mark takes one! If we really intended offering wholesome advice to this company, we'd employ the first two words of this paragraph. Get it?

The following letter explains itself—and "do not make no clinkers":

West Newton, Pa., Jan. 5--14.

W. S. Kuhn, the Elec. Co. of Pittsburgh, Pa.

Sir—Having seen the biggest mergers of electric co. I wish to draw your attention to a fuell saving device and labor saving. it is in the form of a simi circler bridge wall. when propley placed in by a expert. I guarnte to save 66% of fuell, and do not make no clinkers. makes perposanetley less smoke. and also burns all the smoke that is combustable. as a small quantity is uncombustable as it contains too much watery vapor and that cannot be burned. this device is onley good for horrisontal boilers, such as return tublers, silinders and flew boilers. and I guarnte to give more and better steam with one boiler, then two of heny other boiler on the marKet. of the same horse power. if you accept this offer for me to place you one in free of charge. will not cost you one cent. and you to make an affedavit to the effect of its merrits. and answer 25 inquires as to its eficancy. it is as astounding as the arepaleen. if you wish to give this a triall let me Know when i can se you and were. and we can soon arange to have it don. at the shortist notice. in ordering give the diametr of the boiler. Patent appid for.

Yours truly,

(Signed) ——— ———

P. S. as soon as i get this placed I want to make a trolley that will not come of the wires in rounding a turn. i have seen them com of on the strait lines also.

Flexible Gusset Stay

A flexible gusset stay adapted chiefly to Lancashire boilers has been introduced in England by the Vulcan Boiler & General Insurance Co., Ltd., of Manchester. The flexible stay is shown in Fig. 1 and is a modification of the ordinary rigid gusset stay, consisting of the usual double angles riveted to the shell and front end plate. The gusset web plate is rigidly riveted to the angles on the shell but instead of the rivets usually used, for the attachment of the web plate to the angles of the front end plate, turned bolts are substituted. The bolt holes in the gusset plate are elongated, the clearances varying from a maximum at the bottom to nothing at the top and in this way a certain amount of end-plate movement is permitted before the stay comes into operation. By varying

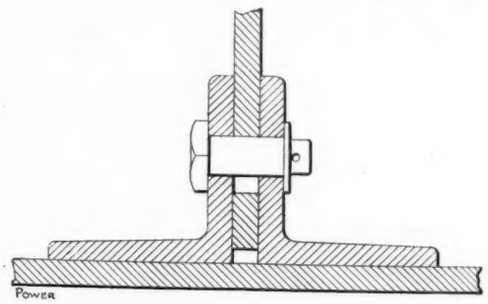


FIG. 1. SHOWING ELONGATED BOLT HOLE IN GUSSET STAY

the elongation of the bolt holes it is possible to design a stay so that the end plate is free to move through any predetermined distance and moreover by this system the load can be distributed evenly over all the bolts, whereas in the ordinary system of rigid staying, practically the entire load comes on the toe rivets only. When the conditions of working are severe, such an arrangement of staying is of great value in reducing the strains that tend to cause grooving or leaking at the rivets and seams on the front end. With rigid staying practically all the movement due to furnace expansion has to be taken up by the front-end flanges of the furnaces and a strip of plate usually about 10 to 11 in. wide situated between the crowns of the furnaces and the bottom or toe rivets in the attachment of the gusset angle to the end plates. With the Vulcan system of staying, the deflection is not localized, but is distributed over that portion of the end plate situated between the furnace crown and the outer circumferential riveting by which the plate is attached to the shell and the angle through which the plate is bent to this movement is comparatively small. Hence severe local stresses are avoided.

These stays have been used in boilers and have stopped leaks that were troublesome with rigid gusset stays. The chief purpose of this stay is to prevent grooving due to distortion of the head by the expansion of the furnace plates.

The curves, Fig. 2, show the deflection of the head, furnace plates and the bottom of the stays in a Lancashire boiler. The boiler tested was 8 ft. in diameter, made for an ordinary working pressure of 160 lb. The end plate was ¾ in. thick, fitted with five flexible gusset stays above the furnace at the front end and two ordinary rigid gusset stays below. The bottom bolt hole of the center stay was elongated $\frac{9}{32}$ in., those in the intermediate stays ¼ in., and in the wing stays $\frac{5}{32}$ in. It

will be noted that the deflections of the boiler under steam pressure were much greater than the corresponding cold-water pressure, due principally to the fact that the expansive movement of the furnace forces out the end plate. steam pressure the expansion was just equal to that produced by the maximum cold-water test pressure of 260 lb. per square inch. The deflection of the bottom ends of the three center gusset stays were of a similar amount

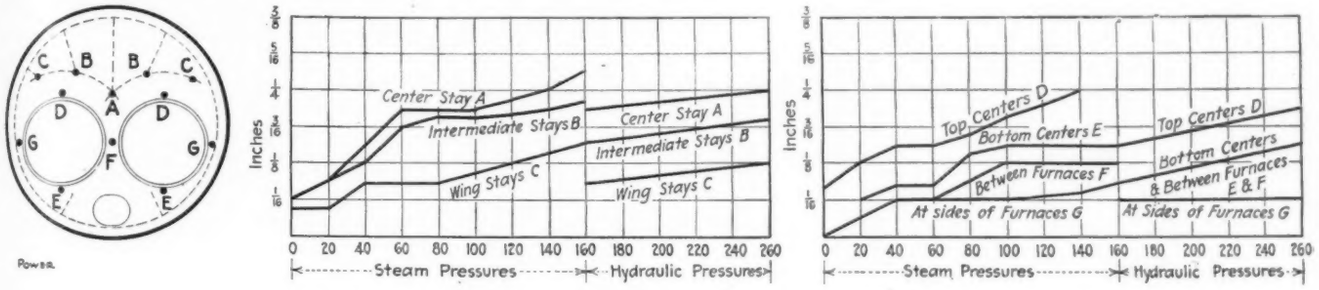


FIG. 2. CURVES OF DEFLECTIONS IN BOILER AND FURNACE

When steam at about 212 deg. F. was just issuing from the test tap, the upper parts of the furnace were expanded $\frac{1}{16}$ in. more than the shell of the boiler, while at 40 lb., steam pressure the difference at these parts equaled that caused by a cold-water pressure of 160 lb. At 120 lb. and at the full working steam pressure of 160 lb. the bolts were just in contact with the ends of the elongated holes in the gusset plates. Hence the end plate was practically free to move forward until the full working pressure was reached.

Oil Burners for Power Plant

BY J. J. MCINTOSH

SYNOPSIS—The use of air and steam for atomization and different types of burner on the market.

For power-plant work steam is almost entirely used in the burners as an atomizing medium. The extra equipment required for air for this purpose is a serious drawback to its use. It not only increases the complication of an oil-burning system, but also adds to the risk of interrupted service. As it is convenient to use steam for this work and as air for atomizing offers no advantage over steam by saving fuel, air is never used unless there is a special reason for it. The amount of steam used for atomization varies in different plants. If the furnace

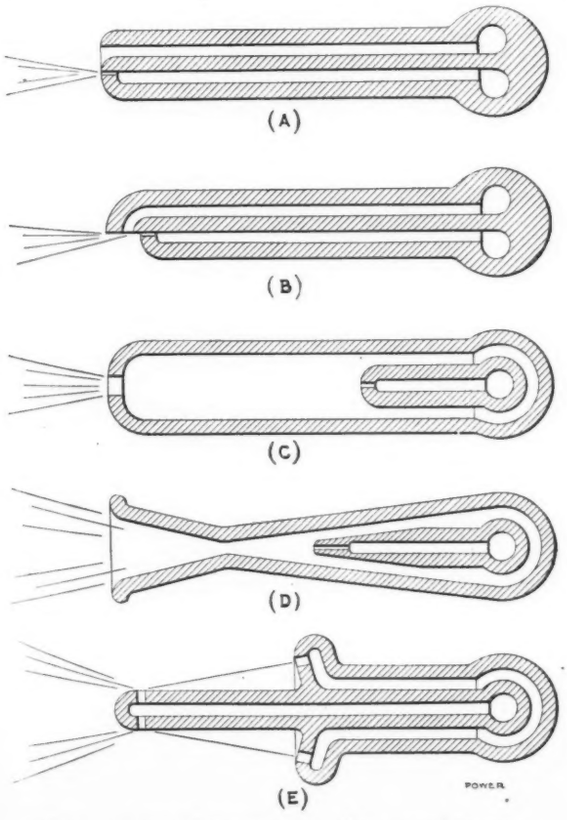


FIG. 1. FIVE GENERAL CLASSES OF BURNER

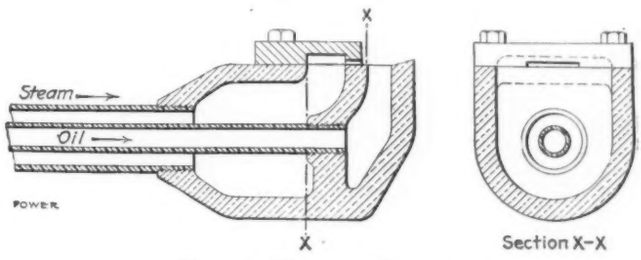


FIG. 2. WORDEN BURNER

temperature is high and the oil fed to the burners is preheated, it will require less force to atomize the oil. Oils with an asphaltum base are heavy and of a viscous character, and by increasing their temperature their viscosity is rapidly reduced. If the furnace is properly arranged,

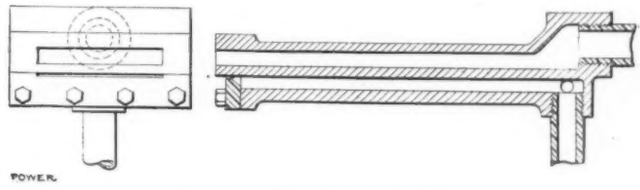


FIG. 3. BOOTH BURNER

the amount of atomizing force required will be small, because the heat from the brick will immediately gasify the oil, and, if sufficient oxygen is present, it will ignite and complete combustion will ensue. Atomizing a pound of oil requires from 0.25 to 0.5 lb. of steam.

Air is used almost entirely for atomization in certain industrial operations where a high furnace temperature is desired. It is used also in cement kilns where a long flame is desired and in operations where steam would have a detrimental effect on the products manufactured. It is still being used to a certain extent on ocean-going vessels but is slowly giving way to mechanical atomization. As space is at a high premium on such vessels, and, as steam for atomization would require from 3 to 8 per cent. of the total water carried, its use is limited. The oil pressure is kept in accordance with the temperature to prevent the formation of gas. However, the moment the oil leaves the burners under the boilers, the pressure is removed from the oil, and it flashes into the finest atoms. This physical action is assisted by centrifugal spray nozzles, so as to give a more perfect and intimate mixture with the air.

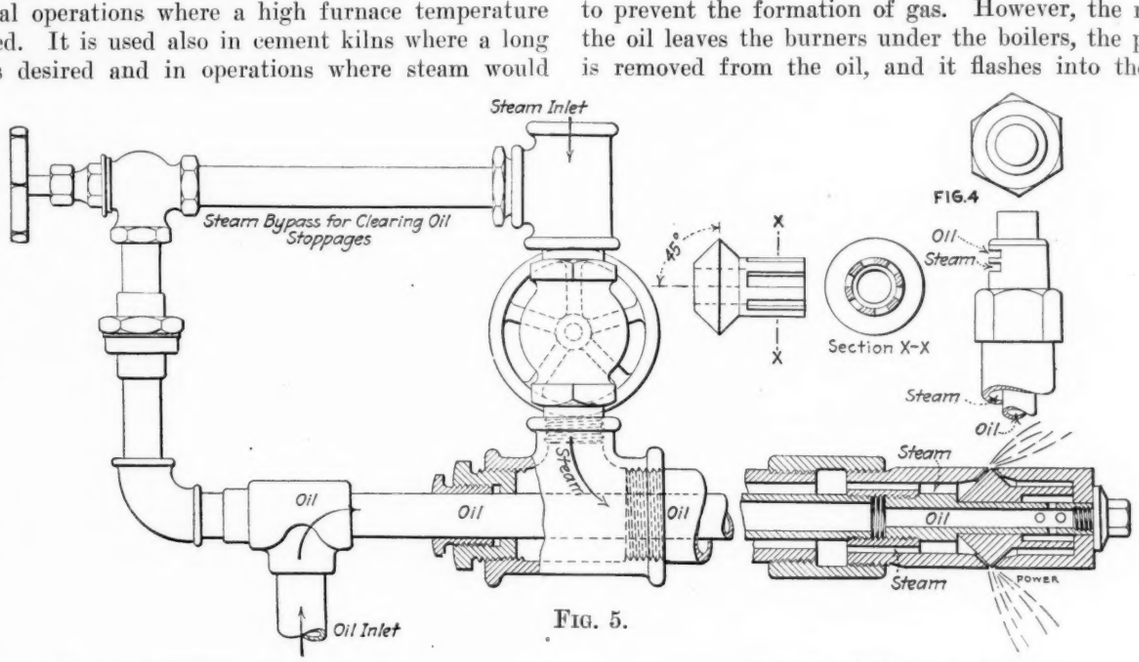


FIG. 4. PEABODY NO. 1 BURNER

FIG. 5. MCDONALD BURNER

BURNERS

There have been hundreds of oil burners designed, but the majority of them never got further than the paper on which they were laid out. It has been the pet hobby of many engineers—and others—to design oil burners. As a matter of fact, the design of an oil burner is not amount of air required varies considerably, but usually ranges from 0.2 to 0.55 lb. per pound of oil.

Oil is also atomized by mechanical action. The oil is heated to a high temperature (about 260 deg. F.) and the

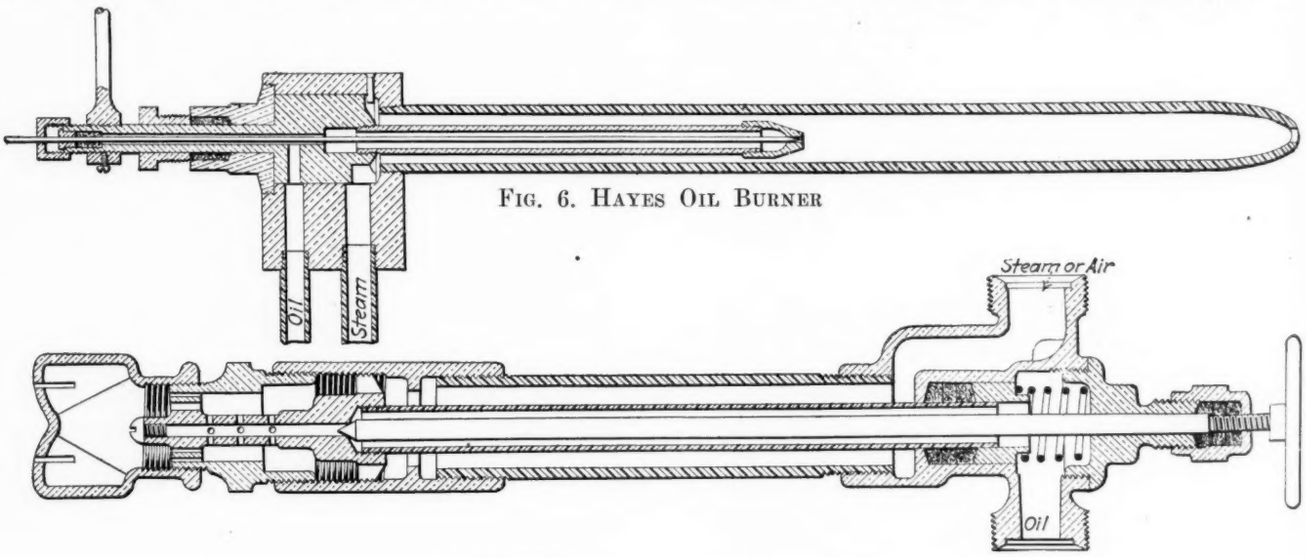


FIG. 6. HAYES OIL BURNER

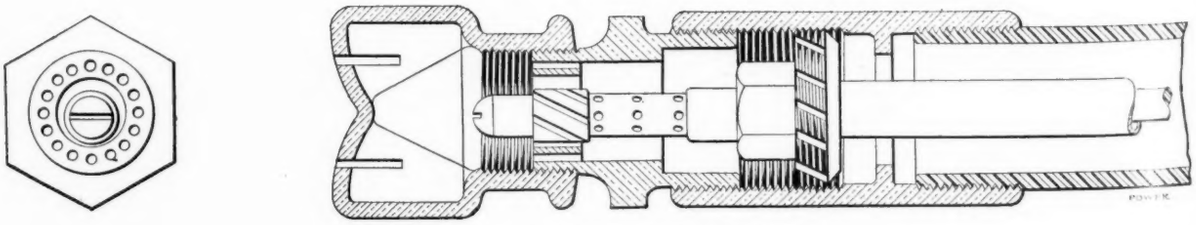


FIG. 7. STAPLES AND PFEIFFER BURNER

nearly as important as the arrangement of the furnace in the economic burning of oil. This does not mean that any sort of a contrivance that will squirt oil into the furnace will do for an oil burner. Oil must be gasified or broken up into a fine spray before it can be burned completely. If the oil is not broken up into a fine spray or gasified, complete combustion will not ensue, and small particles of unconsumed oil will fall to the brickwork, forming carbon, which will accumulate and build up; this condition, of course, represents a waste. Provided that a burner completely atomizes the oil, nothing further in the design of a burner will result in a higher economy, with the exception of the amount of atomizing agent required to bring this about. The best burner is obviously the one that completely atomizes the oil with a minimum amount of steam or air. It must also be designed to permit rapid removal from the furnace for examination and all parts subject to wear must be made easily renewable.

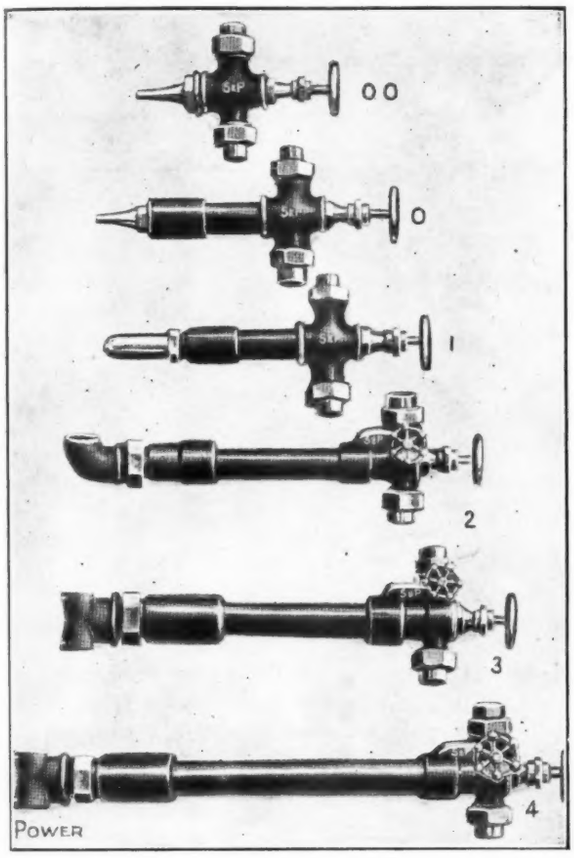


FIG. 8. STAPLES AND PFEIFFER BURNERS FOR MELTING METALS AND FOR BOILER USE

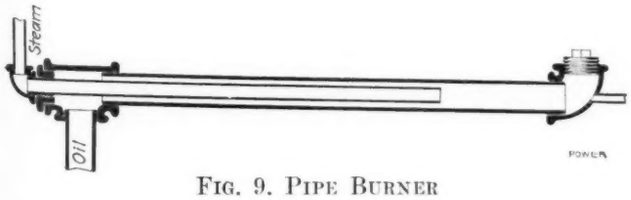


FIG. 9. PIPE BURNER

The first burners to mechanically atomize oil were not successful when used with oils containing an asphaltum base, because this type of burner has a tendency to carbonize the oil. The carbonized oil stops the passages and hinders the working of the burner. In several types of mechanical burner now on the market, this tendency to carbonize seems to have been entirely overcome. In fact, mechanical oil-burning systems are finding a wide application in marine work and have made considerable headway in stationary work.

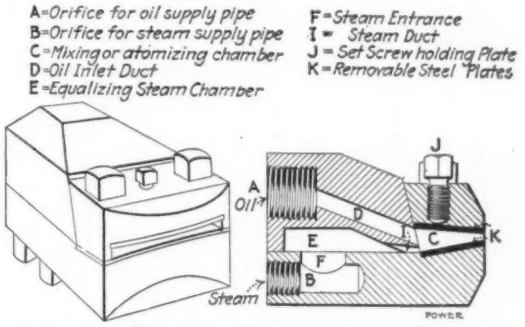


FIG. 10. HAMMEL INSIDE-MIXER BURNER

Of the thousands of patents that have been granted for oil burners, it has been found possible to divide them into five different classes. These five general classes are shown in Fig. 1.

In illustration *A*, the drooling burner, oil drops out of an orifice on a flaring jet of steam and is thus atomized. In the atomizer burner *B* the oil drops directly on the steam jet, or, in other words, is swept off by a brush of steam or air. In the chamber burner *C* oil and steam intermingle within the burner itself and issue from it in the form of a mixture. The oil is further broken up by the expanding action of the steam as it leaves the burner. The injector burner *D* is similar to the steam injector. Its design enables it to draw oil from a tank and force it into the furnace. In the projector burner *E* oil is pumped to the burner and in issuing from the burner tip is taken up by a jet of steam.

Burners may be further divided into the outside- and inside-mixer types. In the outside-mixer type of oil burner, the oil and the atomizing medium do not come into contact with each other until they are forced into the furnace. In some types the oil enters the furnace through an orifice, in the burner, above the steam orifice, drops upon a jet of steam and is thereby atomized. In other types the oil issues from the burner below the steam, but the orifice is so designed that the oil leaves the burner at nearly right angles to the jet of steam. As a result the oil jet strikes the steam jet and is thus broken up into fine particles.

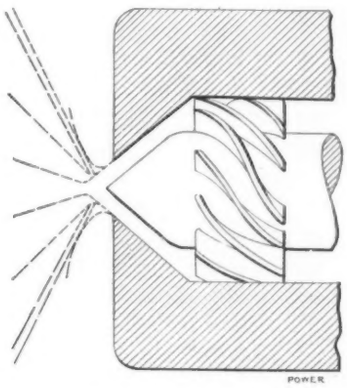


FIG. 11. FORMATION OF SPRAY IN MECHANICAL BURNER

In the inside-mixer type of burner, the oil and atomiz-

ing medium come into contact with each other before leaving the burner. The result is that the oil is broken up within the burner itself. The adherents of this type of burner claim that it will atomize either cold or heated oil with better success than the outside-mixer type.

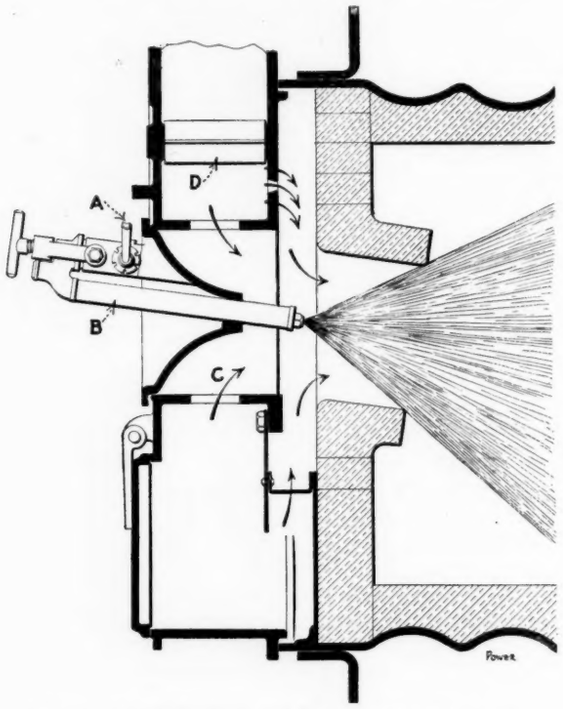


FIG. 12. KOERTING MECHANICAL BURNER

Fig. 2 shows the Worden burner, which is of the outside-mixer type. It will be noticed that the oil flows from the burner at right angles to the jet of steam. Fig. 3 illustrates the Booth burner, which is commonly called the Santa Fé burner, because of its wide application on the locomotives of the Santa Fé Railway Co. Fig. 4 illustrates the Peabody No. 1 burner, which is used to a large extent on Babcock & Wilcox boilers. The McDonald oil burner is shown in Fig. 5. The action of this burner is similar to that of the atomizer burner shown at *B*, Fig. 1. This burner issues a round flame.

Fig. 6 shows the Hayes oil burner, which is essentially an inside-mixer burner and issues a round flame. Fig. 7 illustrates the Staples and Pfeiffer oil burner and Fig. 8 shows burners of the same make. No. 00 is for melting brass, copper, lead, etc.; No. 0 is for melting steel and iron and also for heating steel and iron for bending, flanging, etc.; No. 1 for tempering, forging, annealing and for brick and lime kilns; No. 2 for bakeries, ovens, retorts, heaters and small boilers; No. 3 for all standard makes and sizes of boilers, furnaces, kilns, etc.; No. 4 for large boilers and furnaces in general.

Fig. 9 shows a pipe burner that is popular with some engineers. It is of the inside-mixer type. The orifice in the ell should be about $\frac{3}{32}$ in. in width and the length of the orifice will depend upon the width of the furnace. The end of the steam pipe in the burner should be about 6 in. from the orifice.

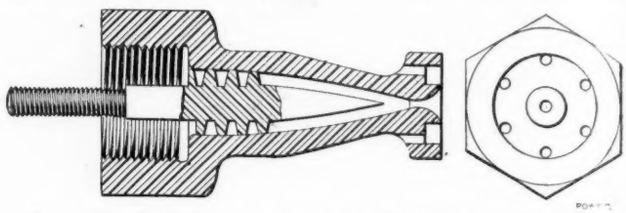


FIG. 13. HEAD OF ANOTHER KOERTING BURNER

Fig. 10 illustrates the Hammel inside-mixer burner which is held in high regard by many. It has been estimated that there are over 10,000 of these burners in use.

Fig. 11 shows the formation of spray in a mechanical burner, under the joint action of the pump pressure and the centrifugal action of the screw-guide blades. Fig. 12 shows the Koerting mechanical oil burner in action. In the drawing *A* is the oil inlet, *B* the burner, *D* the damper and *C* the air inlet. Fig. 13 shows the burner head of one form of Koerting burner.

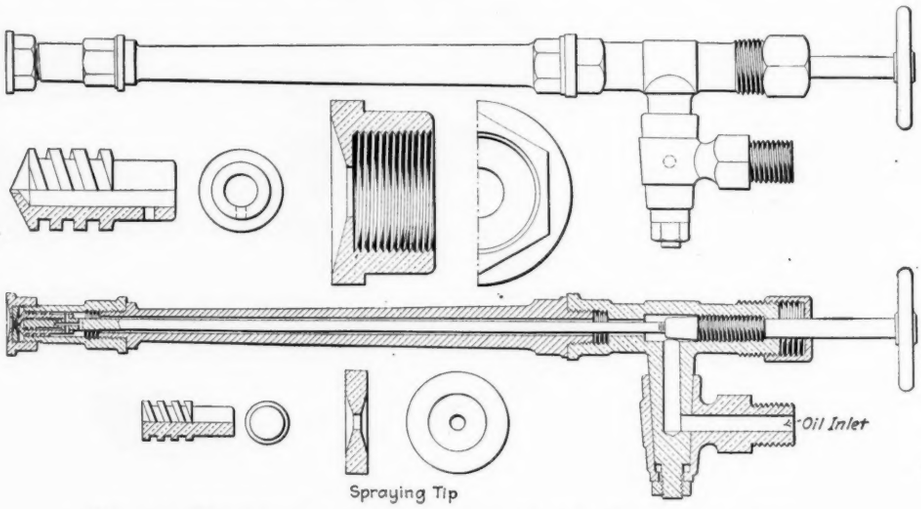


FIG. 14. MECHANICAL BURNER USED IN OIL FIELDS OF RUSSIA

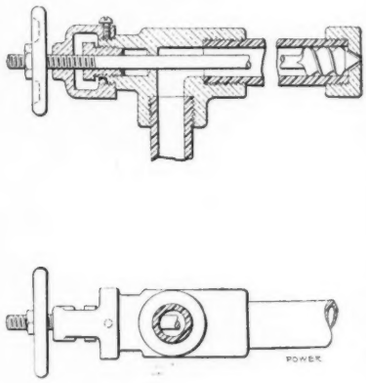


FIG. 15. MECHANICAL BURNER USED BY U. S. NAVAL FUEL-OIL BOARD

Fig. 14 illutsrates a form of mechanical burner used in the Baku oil fields in Russia, and in Fig. 15 is shown a mechanical oil burner designed for use by the United States Naval Fuel Oil Board.

The burners illustrated in Figs. 2, 3, 4, 7, 9 and 10 produce a flat fan-shaped flame, and experience has proved that burners producing a flat flame are the most efficient for the majority of stationary boilers.

Composite Generating Plant

By H. Winfield Secor

SYNOPSIS—In the daytime, alternating current is supplied by a turbo-generator and direct current through a synchronous motor-generator set. At night, the alternating-current load is much smaller than the direct-current, hence the turbo-alternator is shut down, and an engine-driven dynamo started. Alternating current is then supplied by the motor-generator set reversed.

This generating plant was designed to supply both three-phase alternating current at 250 volts and direct current at 220 volts for the Pennsylvania Railroad Co.'s locomotive repair shop at Trenton, N. J. Besides, there are two Thomson-Houston series arc-light dynamos supplying direct current at 8500 volts for arc lamps throughout the shop and yard.

The prime movers comprise a 500 kw. turbo-alternator delivering three-phase alternating current at 250 volts and 60 cycles; a 200-kw. synchronous motor-generator set with a 220-volt compound-wound generator delivering direct current to some of the apparatus about the shop, particularly the crane motors, and finally, an auxiliary source of direct current at 220 volts from a 200-hp. tandem compound engine-driven unit.

There are two exciters, each driven at 1500 r.p.m. through a 10 to 1 reduction gear by a 75-hp. De Laval turbine. One of these exciter units is run during the day and the other at night. The plant is operated condensing for the large engine and turbo unit. The 500-kw. turbine is started slowly noncondensing, and, after it has reached normal speed, is thrown onto the condenser. It is never started on the condenser, as the water-sealing arrangement of this turbine does not become effective until practically normal speed has been attained.

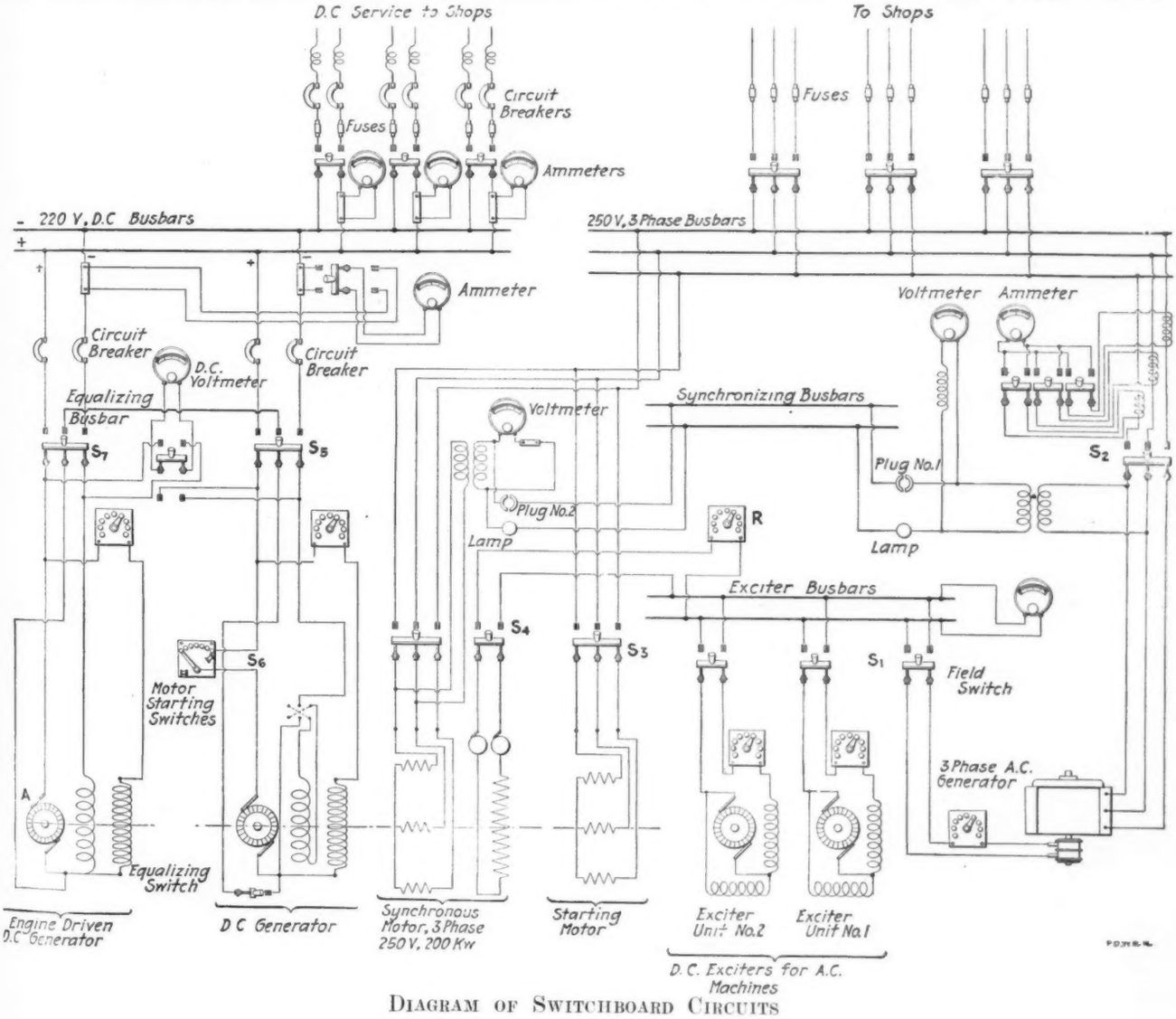


Diagram of Switchboard Circuits

The main switchboard is divided into two sections of five panels each. The right-hand section is for the alternating-current switching apparatus, including the exciters, while the left-hand side controls the direct-current units and circuits.

The regular daily procedure in running this plant is as follows: One of the exciter units is started and its

voltage adjusted to about 115 volts. At the same time the 500-kw. turbo-alternator is brought up to speed and the field excitation switch S_1 is closed. The alternating-current voltage is then adjusted by means of the field rheostat, or, if necessary, by regulating the exciter voltage, and the main switch S_2 is then closed, making the main busbars alive, so that any desired alternating-current service is readily supplied by closing the proper shop-circuit switches. The fuses only protect the alternating current section of the switchboard and its supply units from overload or short-circuits on the shop lines, the generator panels having no protective devices.

As some direct current is required for the motors and other devices, such as heaters, annealers, etc., the synchrononous motor-generator set is used to supply this service. This set is brought up to synchronous speed by a squirrel-cage induction motor directly connected to the shaft. After having attained approximately synchronous speed the field excitation switch S_4 for the synchronous motor is closed, and the synchronizing plugs 1 and 2 are inserted in the receptacles. When the set approaches synchronism the main motor switch is thrown in quickly. The motor is now ready to take its load, and the switch S_3 on the starting motor can be opened. If difficulty is had in synchronizing the two machines, the starting motor switch may be opened and closed quickly, so as to slightly change the phase relation between the motor and the alternator. This may have to be done several times before the operator can get the "dark" period sufficiently long to enable him to switch in the set.

After the motor-generator set has been synchronized and the direct-current potential adjusted to 220 volts, by means of the shunt field rheostat, the generator switch S_5 can be closed, thus energizing the direct-current busbars. The circuit-breakers are always closed before the main switch, for in case of unforeseen trouble on the line, if the circuit-breakers were closed manually after the switches they would not offer any automatic protection, and serious damage to the generator might result.

It is to be noted that the special direct-current motor-starting switch S_6 is equipped with suitable resistance sets which are always left closed when the machine is to be operated as a dynamo to supply 220 volts to the switchboard.

The plant is now running under normal day conditions, and toward evening, when the time approaches to shut down the 500-kw. alternator and the synchronous motor-generator set (operating as a motor), the steam-engine-driven unit is brought up to speed and its voltage adjusted to correspond with that of the direct-current dynamo of the motor-generator set. First, the circuit-breakers of the incoming machine and then the switch S_7 are closed. The load on both direct-current generators is quickly balanced by manipulating their field rheostats, and as the direct-current end of the motor-generator set is to be cut out, the load is reduced to approximately zero by cutting out resistance in the field circuit of the incoming machine and cutting in resistance in the field circuit of the outgoing machine. When the ammeter on the latter indicates practically zero load its main circuit-breakers are tripped, cutting it out of service. From the foregoing it is evident that the direct-current load on the switchboard has been carried right along without any interruption, by operating the two direct-current generators in parallel for a short time.

At this stage the usual practice is to cut off temporarily all the alternating-current load by prearrangement with the shop department, and the shop-circuit switches are accordingly opened when the load has dropped to a very low point. The synchronous motor of the set is also cut out by opening its main switch and then its field excitation switch S_4. This leaves the motor-generator set dead. The alternating-current load having been reduced to zero, the 500-kw. turbo unit has its main switch S_2 opened, but just previous to this its field excitation switch S_1 is opened, only half way at first, allowing the blades to engage with the field discharge resistance for a few minutes, which prevents the sudden production of a high induced electromotive force, which might puncture the field windings. The throttle on the steam turbine is then closed and the turbo-alternator is brought to rest. The exciter unit is also shut down.

Usually, some alternating-current service is desired at night. This is supplied from the synchronous motor-generator set operated as a three-phase alternator, excitation being furnished by the spare exciter. The direct-current machine is readily started now as a compound motor. In order that the series and shunt windings shall not oppose one another, however, it is first necessary to reverse the series field connections by means of the double-throw switch shown. The circuit-breakers are next closed, then the main switch, and finally the starting switch S_6 is slowly closed step by step until it is all the way in and the set has attained normal speed. The field excitation switch S_4 of the synchonous machine is then closed, and the alternating-current three-phase voltage is adjusted by means of the field regulator R, and also the exciter's field rheostat, if necessary. When the alternating-current voltmeter indicates the correct potential, the main switch may be closed, and the busbars are made alive. If desired, the alternating-current load on the turbo-alternator could be transferred to the motor-generator by starting up this set as just described and then synchronizing the two alternating-current machines to prevent interruption of service.

It is poor practice generally to solidly connect (electrically) a large synchronous motor and an alternator, without automatic circuit-breakers in the line. Sometimes the direct-current load on the generator becomes too great and the synchonous motor, owing to its inherent characteristics, refuses to stand up to the load and comes to a dead stop. The motor, with but little resistance and fair impedance, is short-circuited directly across the line of the alternator and throws a heavy load on the latter unless the motor switch is very quickly opened. This occurred once in the writer's experience, and before the motor switch had been opened the alternator started to smoke. This took place about 11 a.m. and the alternator stood up for the rest of the day, but that night the revolving bipolar field gave out and necessitated calling out a night shift to put in a spare field, which luckily was on hand. One of the revolving field coil terminals had become charred until it could barely hold together, and finally parted, thus opening the field circuit. All this trouble, and any repetition of it, could have been avoided by installing circuit-breakers on the alternator panel, or at least by putting a set of fuses between it and the main busbars.

Transit and Level for Engine Aligning

By L. L. Brewster

SYNOPSIS—Directions are given for using an engineer's transit and level in aligning an engine, the installation of a gas engine being used as an example. The value of the instrument for other work is also pointed out.

An engineer's transit, when available, is a valuable aid in quickly and accurately doing the aligning incidental to setting up any form of steam or gas engine or compressor unit, as well as line shafting. If the transit is accurately adjusted it may be used as a level. If it has no level under the telescope, a surveyor's level can be used.

The method of using the instrument may be understood from the following account of the installation of a large double-acting, twin, tandem gas engine.

Before the engine was placed, a set of reference lines were located on the engine-room floor, as shown in Fig. 1, i.e., the two center lines of the engine and the center line of the shaft. Small plugs were driven in holes cut in the concrete floor at the end of each line. Tacks were driven in the plugs at the point of intersection of two scratches, made with a knife blade.

Two lines *AB* and *CD* were checked by measuring the distance between their ends with a steel tape, setting up the transit over all four points, *A, B, C* and *D,* and successively turning right angles with the transit and "checking in" on the points. The line *EF* is located by "setting up" over the intersection of this line with the lines *AB* and *CD* and checking the angles and distances, as in the case of the base lines *AB* and *CD*. These points were purposely located some distance from the position of the engine to be used as permanent reference points over which to set up the transit and so reëstablish any of the lines at any time.

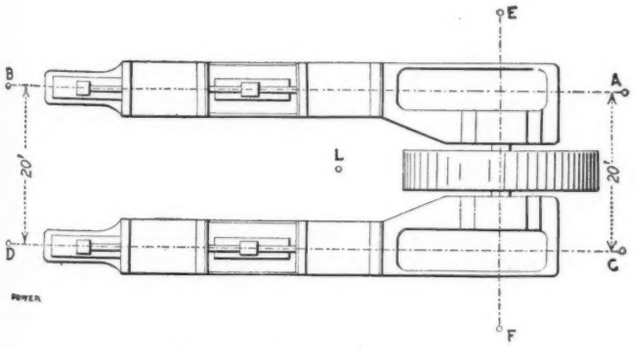


Fig. 1. Center Lines through Engine

When the parts of the engine were placed, their location on the foundation could be very closely established by comparatively rough measurements, and after complete assembly and before the engines were "grouted in" on the foundation, the aligning of the engine was accurately done by using the transit.

Setting the transit over the point *A* and taking a sight on the point *B,* any point on the engine which is intersected by the vertical cross-hair in the transit will be in the vertical plane of the center line of this half of the engine. Since the reciprocating parts of the engine are those which must be on a center in the vertical and horizontal plane it is necessary to accurately check their location. As these reciprocating parts are nearly all circular in section, their centers are accurately located by the contrivance shown in Fig. 2.

Care should be taken that the angle of the two bottom legs is the same on each side of the center line. This center line *GH* should be drawn in the exact center of the flat vertical member, and the plate at the top which supports a machinist's level should also be at exactly right angles to the center line *GH*. Then if the contrivance is placed over a piston rod, for instance, the line *GH* will be vertically over the center line of the rod when the bubble in the level is centered and the line *GH* may be used as the target at which to sight the transit.

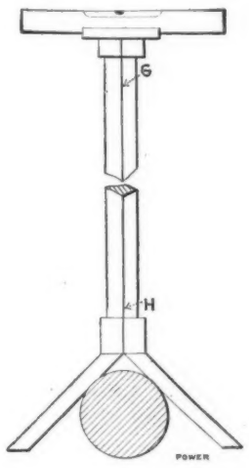


Fig. 2. Centering a Rod

If any part of the engine is out of line, the error will be in the distance between the line *GH* and the line of sight through the transit as previously established from *A* to *B,* Fig. 1. By moving that part of the engine which is out of line until the line *GH* comes into the line of sight through the transit, that part of the engine will be brought into coincidence with the center line of the engine.

Other parts of the engine not of circular section, but the center of which can be accurately established by measurement, can be checked by the use of a plumb bob. All points along the engine can thus be brought into line in a vertical direction usually from a single setting of the transit; the operation for one side of the engine is the same as that for the other side.

In the same manner, by setting the transit over the points *E* or *F* and sighting to the opposite point, the axis of the transit and the line of sight are then in a vertical plane with the axis of the engine shaft and all points along the shaft may be brought into line by methods similar to those just described.

Having accurately located the base lines, in which case it is certain that the axis lines are parallel to one another and exactly perpendicular to the shaft line, the instrument is a positive check and is also an accurate method of aligning the various parts of the engine.

All the work described to this point, however, refers to location of the vertical plane only. To check the parts of the engine for their proper relative elevations, the transit must be used as a level, or a surveyor's level brought into service. The usual leveling-up process of stretching a wire through the cylinders from one end to the other is accurate, but where the engine is long (in the case under description it was over 70 ft.) allowance

must be made for the sag of the wire which is bound to occur.

To do accurate level work the distance from the instrument to the points at which readings are taken (the length of the sights) must be as nearly equal as possible, although for the short distances of the present case the error would be inappreciable. However, if convenient, it is best to set up the level at some such central point as shown at *L*, Fig. 1. By establishing a bench mark at some fixed point on the floor of the engine room, the height of the instrument may be ascertained also the relative heights of all parts in reference to the bench mark.

For those not familiar with the use of an engineer's level and rod, the process of ascertaining relative elevations is as follows:

Suppose we arbitrarily assume a "bench mark" to be, say, 100 ft. above some imaginary datum plane. Then, if the instrument is level and the sight is taken on the rod placed over the bench mark, the rod reading added to the elevation of the bench mark will be the elevation of the line of sight of the level above the bench mark. Suppose the rod reading to be 5 ft. 6 in., then the elevation of the line of sight through the level relative to the datum plane will be 100 ft. plus 5 ft. 6 in., or 105 ft. 6 in. This is known as the height of the instrument.

Suppose, now, it is desired to check up the elevation of the center line of the engine, assuming that the diameter of the piston rod is 12 in. and the reading of the rod placed vertically on top of the tail rod is 2 ft. This means that the top of the tail rod is 2 ft. below the level of the instrument, or its elevation relative to the datum plane is 105 ft. 6 in. minus 2 ft., or 103 ft. 6 in. But, since the diameter of the rod is 12 in., the elevation of its center line will be 6 in. below this point, or at an elevation of 103 ft.

In like manner one may ascertain the relative elevation of any other points on the piston rod, as, for instance, between the cylinders or at the forward end of the head-end cylinder. If these elevations are not the same as at other points, the difference will be accurately known and the elevation may be adjusted until all parts are at exactly the same elevation.

Evidently, subtracting rod readings from the elevation of the instrument will give elevations at the bottom of the rod and the elevation of points anywhere on the engine is thus easily established if their distance above or below the bottom of the rod is known, and this can usually be easily ascertained.

The rod used for this work should have an accurate scale of fine divisions, but usually, for accurate work, a small steel mechanic's scale must be used with the rod. By holding this scale against the rod and using the edge of it as a target line which is to be brought into coincidence with the line of sight through the level, as indicated by the horizontal cross-hair, a very accurate rod reading can be made. The best time to do this work is at night, especially if the engine room is hot during the day time and there is vibration due to other moving machinery.

While the operations described may seem somewhat complex and difficult, they are really quite simple and can be done quite rapidly. The rapidity of operation, however, should not be such as to interfere with accurate work.

The writer has discussed this method of aligning engines with several erecting engineers, and all who use it agree that it is the most accurate and most expeditious method and any engineer with little practice can handle the transit or level and probably do more accurate work than by any other method.

Gravity Values of Oil

In the article in the issue of Jan. 6, "Physical Properties of Fuel Oil," the following equation was given for the relation between specific gravity and degrees Baumé:

$$\textit{specific gravity} = \frac{140}{130 + B}$$

This is perfectly correct for the United States standard degree Baumé, but according to H. H. Hall, of San Francisco, it is not the one commonly used in the oil business. Tagliabue's "Manual for Inspectors of Coal Oil" is in almost universal use. This book gives a table of the relation between specific gravity and degrees Baumé which is based on the equation

$$\textit{specific gravity} = \frac{141.5}{131.5 + B}$$

Incidentally, in the transposition of the above formula to obtain the second one for Baumé gravity, an error crept into the right-hand member of the equation. The formula should read

$$\textit{Baume gravity} = \frac{sp.gr.}{140} - 130$$

The Power Problem in the Electrolytic Deposition of Metals

Power supply for the refining of metals by electrolysis and electroplating, is different from that for any other purpose. The voltages used are relatively lower and the current of higher amperage than in most other applications, and the conditions so different that they can be met only by apparatus of special design. Satisfactory and reliable service are of prime importance, and economy the next consideration. In the solution of the problem there have been involved the efforts of the three professions represented by the American Electrochemical Society, the American Institute of Electrical Engineers and the American Society of Mechanical Engineers so that it was quite appropriate that the New York sections of these three societies should have one of their monthly meetings a joint one for the consideration of this topic. Such a meeting was held Jan. 9, in the Engineering Societies Building with C. O. Mailloux, president of the American Institute of Electrical Engineers, presiding.

The requirements in the problem from the standpoint of the electrochemist were presented in a paper by Lawrence Addicks. F. D. Newbury, for the electrical engineers, dealt with the sources of direct current for electrochemical processes and H. E. Longwell treated the mechanical side of the question in the selection of the most suitable prime mover.

The electrolytic refining of copper is one of the largest of the industries concerned. Most copper today is so refined and the principal plants doing the work are in the vicinity of New York, so that it was natural that this special phase of the subject received most discussion, particularly as it could be taken as typical of this class of electrolytic processes.

CONDITIONS OF THE PROBLEM

Considering only the so called multiple system of refining, where the electrodes in a tank are in multiple, and the tanks on a circuit in series, the following power limitations are imposed by present practice:

(a) Direct current (obviously required by the nature of the process).

(b) An amperage of, say, 8000 to 15,000, fixed by the current density and the electrode surface per tank. Around New York a current density of about 20 amp. per sq.ft. of ac-

tive cathode surface is used and as much electrode surface per tank as in 30 pairs of electrodes each 3 ft. square.

(c) From 100 to 200 volts per circuit would appear to be the practicable limits of voltage with a preference toward the lower, or not to exceed 150 volts.

(d) For a typical case then a unit of about 1000 kw., although larger than most now installed, is the probable size for a new installation.

(e) Difficulties arising from the tendencies for current leakage indicate the desirability of electrically independent circuits.

(f) Uniform conditions are essential calling for constant current and voltage varying not more than 20 per cent. either way from normal.

(g) The load factor will be practically 100 per cent. for both momentary and 24-hr. loads.

(h) It being necessary to heat the electrolyte, steam is needed. Exhaust steam may be used and, roughly, one-fourth of that from the engines will answer. Additional steam is required for light, power, compressed air and pumping. If the power is other than from steam, waste heat boilers attached to the reverberatory furnaces will supply all steam for electrolyte heating and other uses.

(i) Three thousand to 9000-kw. plants are about the sizes to be considered.

Near New York steam power is logical at present.

Concluding, the author states: "The plant of the future may consist of gas-driven units, of large capacity alternating-current, turbo-generators driving motor generators of smaller size, of compound reciprocating engines exhausting into a trunk main from which exhaust steam turbines are fed, of multiple expansion reciprocating engines, of turbine-driven unipolar generators, or of some combination of these. Spare units must be provided in sufficient proportion to give absolute reliability of service."

ELECTRICAL LIMITATIONS

As to the prime mover, Mr. Newbury declared that in modern installations, steam turbines and waterwheels with their relatively high speed are most important. Reciprocating steam engines are important mainly in combination with low-pressure turbines. So far, gas and oil engines have been little applied, but the rapid development of the Diesel engine may make it a factor.

The large currents and high speeds of the preferred prime movers make the design of direct-current machinery a problem on account of commutation. After dealing with this the speaker took up the distribution problem and the questions of voltage variation and continuity of service.

Summarized, his conclusions and recommendations were:

"Of the methods of power supply using steam turbines that are available:

(a) Direct-connected direct-current turbo-generators are available only in relatively small units, and cannot be designed as conservatively from the commutation standpoint as is desirable.

(b) Unipolar generators driven by turbines have proved unsatisfactory on account of current collection difficulties.

(c) The standard medium-speed direct-current generator connected to a high-speed turbine through gearing affords a satisfactory unit.

(d) The combined alternating-current turbo-generator and converter unit probably affords the best all-around method. It is economical, reliable and flexible. Its particular fields of application are where large units and long transmissions are required.

In waterpower plants, direct-connected direct-current generators and alternating-current generators with converters are available. The combined alternating-current-direct-current equipment is usually the most reliable and economical.

With reciprocating engine units, there is no reason for considering other methods than the direct-connected slow-speed generator.

From the many schemes proposed for the generation of direct current for electrochemical plants, two plans assuming steam-turbine prime movers have decided advantages in efficiency and reliability and flexibility in operation. These are the gear-driven commutator-type generator where the distance between the power plant and the place of utilization is short, and the combined alternating-current generator and synchronous converter plant when this distance becomes too great for economical low-voltage transmission or the units become too large for economical turbine speeds.

CHOOSING THE PRIME MOVER

H. E. Longwell laid particular emphasis in the forepart of his paper on the folly of striving for highest steam or fuel economy when the saving may not be worth while or may entail another loss of even greater magnitude. The extra interest, depreciation, etc., on a more expensive installation may offset the advantage of a higher fuel economy. On this ground the speaker felt that gas-engine equipment could be eliminated from serious consideration, especially as a location could be chosen most favorable for steam-plant economy.

It was figured that the waste heat boilers connected to the reverberatory furnaces should supply enough steam for the auxiliaries and the exhaust from the latter should be enough to heat the electrolyte. Even with gas engine-driven main generating units this heat would need to be utilized. The principal practical difficulty is that the tanks run continuously and the furnaces close down on Sundays, making a considerable stand-by boiler plant necessary. This alone would discount all theoretical advantages of gas power.

The speaker doubts that the reciprocating engine and low-pressure turbine combination would be justified, except possibly where the reciprocating engine is already installed. His leaning is evidently toward the steam turbine alone and he feels that with the reduction gearing now available to reduce the high speed of the turbine to suitable direct driving speed for direct-current machinery, the last objection to the turbine has been removed. While the geared direct-current unit costs more than an alternating-current, turbo-generator unit of the same capacity, it is cheaper and somewhat more efficient than the combination of an alternating-current unit and rotary converter.

Under favorable conditions, the speaker believes a good turbine-driven plant of from 6000 to 9000 kw. can be installed for about $75 per kw., and operated to produce current at about 43 miles per kw.-hr.

DISCUSSION

MR. LEIGHBURY, in the general discussion of the subject, aligned himself on the side of direct current, contending that with all the necessary accessories alternating-current equipment may cost as much as direct current. Further with two stations, one generating alternating current and the other converting the alternating current to direct current, the attendance is increased.

MR. ANTISELL, of the Raritan Copper Co., stated that one point overlooked is the efficiency on part load. There is a greater falling off with turbines than with reciprocating engines.

DR. J. B. F. HERRESHOFF, of the Nichols Copper Co., gave some facts from his experience in that company. Small units (about 400 kw.) were first used, and the turbine was the first in the United States made by the Westinghouse Machine Co., and had a direct-current generator with a long commutator. This company also tried cyclic generators of 2000-kw. capacity, but they were not satisfactory, for 30 per cent. of their energy was given off in heat. Dr. Herreshoff made the statement that no reciprocating engines over 500 kw. are now being built, indicating the practical extinction of engines.

J. B. HERRESHOFF, who has designed alternating-current generators for this class of work, was called upon to discuss the electrical problems. He explained that doubling the current doubles the rate of deposition but requires four times the power. Too rapid deposition is not good as the metal is apt to be crystalline.

C. O. MAILLOUX gave his experience of some years ago in designing equipment for electrotyping. The problem was to make electrotypes faster and uniform in thickness. They were able to use a current density of 500 to 1000 amp. per sq.in. by regulating the feeding of the electrolyte to the cathode. This is not feasible in copper refining. It is theoretically possible to deposit any amount of copper with any amount of power. The speaker recommended a current density of between 15 and 60 amp per sq.in.

C. H. VOM BAUR brought up the subject of oil engines, declaring that current at 0.45c. per kw.-hr. could be produced with them.

MR. ADDICKS in closing the discussion reaffirmed his confidence in the reciprocating engine. The Diesel engine is more economical, but the sources of its fuel are too narrowly controlled and it is not yet sufficiently reliable to be very promising for electrochemical work.

MR. LONGWELL, to prove his disinterestedness, stated that he had designed engines that are now going to the scrap heap and has done no work on turbine design, but he still advocates turbines.

MR. NEWBURY explained his particular reference to steam-driven units, because of their greater interest to the copper-refining industries in the vicinity of New York. Waterwheels are more interesting to the aluminum industries and the larger power users.

Dinner to the Earl of Kintore

On the evening of Jan. 12, a dinner in honor of the Rt. Hon. the Earl of Kintore, P. C., G. C. M. G., was given at the Hotel Plaza. The occasion provided a chance to meet the distinguished guest, who is visiting this country in the interest of the coming Anglo-American Exposition to be opened in London in May. The exposition will be held to celebrate the centenary of peace and progress in the arts, sciences and industries of the United States and the British Empire, it being the centenary of the Ghent Treaty.

Among the guests were Robert C. Morris, George Foster Peabody, Ludwig Nissen, Hon. Oscar S. Straus, Dr. W. P. Wilson, Hon. George W. Wickersham, Dr. Albert Shaw, Hon. Alton B. Parker, Hon. Seth Low, Henry Clews, George F. Kunz, Robert Underwood Johnson, William B. Howland, Isaac N. Seligman, Benjamin F. Tracy, Don C. Seitz, Dr. Alexander C. Humphreys, Fred R. Low, Calvin W. Rice, Prince Sapieka and R. Ross Appleton.

Harvard College in Merger with the Massachusetts Institute of Technology—The engineering departments of Harvard University and the Massachusetts Institute of Technology are to be combined, as the result of an agreement reached tonight, according to the daily press. Heads of both institutes said the plan for coöperation constituted the most important movement toward the conservation of educational forces that the country has ever known. By the agreement the combined departments of mechanical engineering, electrical engineering, civil and sanitary engineering and mining engineering and metallurgy are to be conducted in the new buildings of the institute, now in process of construction in Cambridge. Harvard is to discontinue its schools of applied science in these departments. The president of Technology is to be the executive head of the coöperative work, and the faculty will consist of the faculty of the institute, enlarged by the addition of Harvard professors of the departments involved. Provision is made that when, in the future, the corporation of Technology selects a president, the president of Harvard is to sit with the committee on selection. It was announced that both Harvard and Technology are to remain absolutely unaffected in name, organization and in the title to property. Technology is to furnish the buildings, laboratories and equipment, together with contributions from its special and general funds. Harvard is to give some equipment and the interest on funds that it holds for education and research in these departments.

Civil-Service Opportunities

Competitive examinations for the civil-service positions named below will be held on the dates given. Applications and further information may be had by addressing the respective commission. Candidates must be citizens of the United States and residents of the cities in question, and at least 21 years of age, unless otherwise specified.

Situations for Stationary Engineers—The Philadelphia Civil Service Commission will hold examinations Jan. 31, for three positions of stationary or operating engineer. Salaries up to $1200. Address the Civil Service Commission, room 875, City Hall.

Situation for Gas Engineer—The Philadelphia Civil Service Commission will hold an examination Jan. 31 for the position of gas engineer in the Bureau of Surveys of the Public Works department; salary, $1000. For further information address the secretary of the Civil Service Commission, Room 875, City Hall. Candidates must be citizens of the United States and residents of Philadelphia.

Situation for Marine Engineer—The Philadelphia Civil Service Commission will hold an examination Jan. 31 for the position of engineer of a police-bureau boat of the Department of Public Safety; salary, $1200. Candidates must be citizens of the United States and residents of Philadelphia. For further information address the secretary of the Civil Service Commission, Room 875, City Hall.

SOCIETY NOTES

The Brotherhood of Power Workers, the organization of which at Springfield, Mass., was commented upon in our issue of Oct. 1, 1912, pages 485 and 499, has maintained a vigorous existence, and had an encouraging growth. At one of its recent meetings W. B. Wilkinson, supervising engineer of the Perolin Co. of America, favored them with a lecture upon "Boiler Plate and Tubes."

At the meeting of the Chicago section of the American Society of Mechanical Engineers to be held Jan. 28, Bryant Bannister will present a paper upon a test made at the plant of the National Tube Co., Kewanee, Ill., on a four-pass Edge Moor boiler with Taylor stokers, which gave remarkable results with low-grade Illinois coal. Further information regarding the meeting can be had from C. W. Naylor, secretary, 121 North State St., Chicago, Ill.

An "industrial safety" conference will be held at the University of Nevada, Reno, Nev., Jan. 26 and 27, under the auspices of the Engineers' Club of the University. Representatives of the mining, electrical and transportation industries will participate and a number of exhibits and motion pictures illustrating the safety-first movement will be shown. The invited guests will be entertained at a dinner by the Engineers' Club, during which novelties and recent electrical inventions will be demonstrated.

At the Engineers' Club, Boston, Mass., on Jan. 21, Percy Day, engineer of the Falk Co., read a paper on "Herring-Bone Gears." Mr. Day was closely associated with the development of the Parsons turbine. The herring-bone type of gears is being used on some of the new navy torpedo boats. The evening of Jan. 30 will be "Tech" night at the club, when Dr. Richard C. Maclaurin, president of the Massachusetts Institute of Technology, will give an illustrated talk on "The New Technology-on-the-Charles." A house dinner will be served at 6 o'clock.

PERSONALS

W. L. Abbott, chief operating engineer of the Commonwealth Edison Co., Chicago, has been awarded the Octave Chanute medal by the Western Society of Engineers, as the author of one of the best three papers presented before that society during the year 1913.

George F. Maddock has been appointed manager of the examinations and reports department of H. M. Byllesby & Co., Chicago, succeeding Harold Almert, resigned. Mr. Maddock has been the engineering representative of Byllesby & Co. on the Pacific Coast for a number of years.

OBITUARY

JOHN HYDE

John Hyde, the mechanical engineer for the Henry Phipps properties, died at his home in Pittsburgh, Penn., on Dec. 17, 1913.

J. WALLS

J. Walls, chief engineer of the steamship "Philadelphia," died at Southampton, England, Jan. 6, just as his retirement from the service had been decided upon. During the Spanish-American War, Walls was a lieutenant on the "St. Louis." He had crossed the Atlantic 800 times.

WILLIAM D. MARKS

William D. Marks, a well known consulting engineer, died at Plattsburg, N. Y., on Jan. 7. Prof. Marks was born in St. Louis, Feb. 26, 1849, and was graduated from Yale in 1870 with the degree of PhB. He specialized in civil and mechanical engineering and later received his C. E. degree from the same college. After leaving Yale he engaged in practical engineering work in connection with railways and gas and iron works. In 1876 he became instructor in mechanical engineering at the Lehigh University and the following year became associated with the University of Pennsylvania as Whitney professor in engineering. He was superintendent, in 1884, of the International Electrical Exhibition of the Franklin Institute, and later became engineer and president of the then Edison Electric Light Co., Philadelphia. Prof. Marks was an honorary life member of the Franklin Institute, a member of the American Institute of Electrical Engineers and a member of the American Philosophical Society. He was the author of several books and of many scientific papers and reports.